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Sri-Lanka.

Contact details: vn.attri@iora.int
hq@iora.int

AIMS AND SCOPE OF THE JOURNAL OF INDIAN OCEAN RIM STUDIES

The Journal of Indian Ocean Rim Studies (JIORS) is aimed at strengthening research and academic findings within the Indian Ocean Region (IOR). The overall aim is to enhance the understanding of the issues involved related with the six priority areas as well as Women Economic Empowerment and the Blue Economy of the Association. The JIORS aims at providing a platform for researchers, academics, scholars, resource persons and practitioners to share their research findings which would enrich and enhance stock of knowledge within IORA.

The JIORS is currently seeking research articles, discussion papers or policy papers on the following six priority areas of IORA:

- Maritime Safety & Security;
- Trade & Investment Facilitation;
- Fisheries Management;
- Disaster & Risk Management;
- Academic, Science & Technology Cooperation;

- Tourism & Cultural Exchanges; and;

The Association focuses on two special cross-cutting areas namely:

- Women's Economic Empowerment; and
- The Blue Economy

In keeping with the Charter of IORA, the JIORS would be established to promote research in:

Understanding of sustained growth and balanced development of the region and of the Member States;

Ensuring Capacity Building in the six IORA priority areas of the Association;

Capacity building to create common ground for regional economic cooperation;

South-South Cooperation and issues related to the global economy; and

Matters related to the IORA focus areas of Women's Empowerment and the Blue Economy

JOURNAL OF INDIAN OCEAN RIM STUDIES

Special Issue on Blue Economy, January-June 2020

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FOREWORD

Let me firstly start by extending IORA Secretariat's profound condolences to all who have lost loved ones and we extend wish speedy recovery and all strength to those negatively impacted by this COVID-19 pandemic. We salute all frontline workers, we have them in our deepest thoughts and prayers. This pandemic has dramatically and drastically changed our lives, and this has led to challenges in governance, social-economic cooperation, and the Sustainable Development Goals (SDGs), forcing us to rethink, re-strategize and re-develop our developmental aspirations. As of going to press most countries would be in lockdown or easing it and all borders, land, air, and sea are closed. No country has been immune, as reported are the tragic fatalities and economies have suffered insurmountable losses.

Currently we are seeing a silver lining in the clouds as we are gradually getting back to the new normal using the digital technology being away from the office but at home. Despite this challenge, I am very pleased to know that Prof. V. N. Attri, Chair in Indian Ocean Studies (CIOS) has diligently and successfully compiled the Volume 3, Issue 1 of special issue of JIORS on Blue Economy, despite great difficulties experienced due to COVID-19. Earlier to this issue, the CIOS has uploaded the special issue on Indo-Pacific of JIORS which was launched during the Sixth Indian Ocean Dialogue (IOD) in New Delhi, India on December 13, 2019.

Furthermore it is commendable that within a short span of time being less than 3 years of its inception, Prof Attri has made the JIORS- a

global Journal in which the academic fraternity, researchers and policy-makers from all the Member States of IORA; Dialogue Partners, and even beyond are contributing their scholarly articles on IORA's six priority areas and two cross cutting areas. Thus, the visibility of IORA has been greatly enhanced with the regular on-line publication of the JIORS.

The Blue Economy was adopted as new development paradigm in IORA on October 9, 2014 during CSO/ COM meetings in PERTH, Australia, during its chairmanship of IORA. Earlier to this, in 2013 in PERTH- "PERTH Principles" were unanimously adopted by the Member States of IORA, focusing on Sustainable use of Oceanic Resources in the Indian Ocean Region.

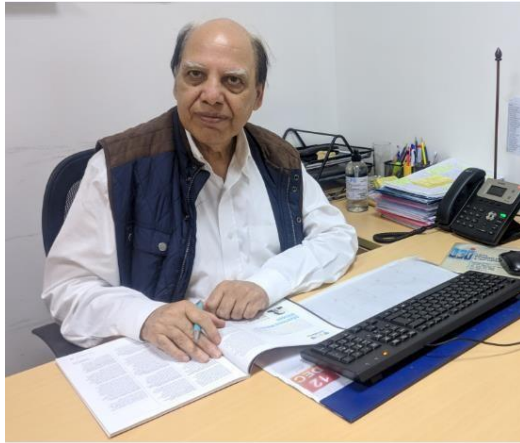
The COVID-19 pandemic is unprecedented in our lifetime, impacting negatively not only all economies around the globe but IORA's key priority areas. The countries are implementing policy responses and trade measures with different philosophies, time, scales, and levels. According to UNCTAD report (2020), "The Blue Economy accounts for about 3.5 to 7 percent of global GDP. Blue Economic sectors, those largely relying on the marine environment, ecosystems and species to generate economic value, are being heavily impacted. The pandemic is not only limiting global fishing efforts but also hampering production of other maritime goods and services, affecting dependent value chains globally." All the sectors of the Blue Economy are heavily affected including travel and tourism; maritime transport; fisheries and seafood production. The Sustainable Development of Blue Economy is important, even despite severe challenges for achieving sustainable development paths, consistent with the 2030 Agenda for Sustainable Development and, Sustainable Development goal 14: *Conserve and sustainably use the oceans, seas, and marine resources*. IORA is strongly committed to the Sustainable Blue Economy by its resolutions of three Ministerial Conferences on Blue Economy in 2015 in Mauritius; 2017 in Indonesia, and 2019 in Bangladesh. It is believed by the Experts globally that despite its preexisting challenges

such as levels of plastic pollution and other chemical pollution, greenhouse gases (GHG) emissions, and over exploitation of resources, policy makers must additionally face the impacts of the pandemic and seize opportunities for quick economic recovery- leading to generation of gainful employment in Blue Economy sectors as soon as lockdown measures are lifted.

We need to find innovative technologies of production through multilateral economic cooperation; and undertaking specific studies on different sectors of the Blue Economy in reference to promoting gender equity and generation of employment for our youths- especially women. The special issue of JIORS consists of theoretical, practical, and empirical studies related with Blue Economy.

I would like to congratulate the CIOS and his team in bringing out this special issue on Blue Economy. Hope this issue will generate discussions among the academicians and researchers and policy makers on the effectiveness of Blue Economy during this descriptive pandemic period in reviving the global economy- including IORA Economy.

H.E. Ambassador Dr. Nomvuyo N. Nokwe
Secretary-General,
Indian Ocean Rim Association
hq@iora.int



MANAGING EDITOR FOREWORD

The Sustainable Blue Economy is an interdisciplinary “Alternative Development Paradigm” focusing on sustainably using the Oceanic Resources through implementing all the sub- targets of SDG 14 - 14.1 to 14.7 (a, b, c). Not going into the details of these sub-targets, I am sure that this particular goal may help in fulfilling the main outcomes emerging from the Ocean Economy, making it Sustainable, inclusive, and generating gainful employment for our youth- especially women to ensure Women Economic Empowerment during this current and post Pandemic era of COVID-19. In my opinion, the emerging innovative contours of Green- Blue Economy leading to innovative financial instruments being supported and promoted by the World Bank and other International Financial institutions, including the corporate sector globally, Regionally, and at National level.

The Blue Economy emphasizes the efficient use of local coastal resources, available in the ecosystems; and, therefore, localization of emerging new Oceanic industries is a natural and logical byproduct of Sustainable Blue Economy- leading to Sustainable Development and inclusive growth at local, national, regional and global level .

The truer Implementation of Sustainable Blue Economy is linked with other Sustainable Development Goals such as SDG -12 ; SDG-13 and SDG - 15 , under the overall

implementation of SDG-17 “Global Partnerships” which seems to be the best way to achieve the United Nations SDGs by 2030 which were adopted by the nations in 2015.

The central axiom of the Blue Economy is “Sustainability” and it is only the sustainable use of all the resources on the planet Earth that would make it possible to happen “The Future we Want”- as envisaged in UN Report (2012). Sustainability consists of Economic, Environmental and Social dimensions. The new waves of investments, New Technologies, and Innovative partnerships suggest that an era of genuinely Sustainable Blue Economy is just around the corner.

The present special issue on The Blue Economy of JIORS is a mix of Research papers and one report on Blue Economy which makes this issue a blend of theory and practice, so essential for the understanding of the issues involved in the Blue Economy.

The paper entitled, “Initial Measures of the Economic Activity linked to Bangladesh’s Ocean Space, and Implications for the Country’s Blue Economy Policy Objectives,” by Pawan Patil reviews the initiatives undertaken by the Government of Bangladesh. The country resolved its maritime boundaries in 2014, resulting in jurisdiction over ocean space equivalent to 80% of the Bangladesh’s terrestrial area. To encourage the development of this area and the resources it contains, the Government embraced the concept of a “blue economy” in its most recent development plan, as a broad label for all ocean-linked economic activities that are environmentally and socially sustainable. The Government’s intention to design blue economy policies will need to be supported by extending the analysis in this study to a full ocean economy satellite account, eventually adding measures of the economic value of marine ecosystem services and the costs of environmental degradation, as well as the status of the underlying stocks of natural capital.

The paper by Jean-Louis Weber, "Towards Ecological Governance Based on Ecosystem Natural Capital Accounting" focuses on the Ecosystems Natural Accounting framework (ENCA). The ENCA methodology is an accounting framework which addresses all ecosystems and being based on spatially explicit data and statistics, it can be implemented at any scale, by socio-ecological geographical units as well as for countries, local governments and enterprises. Ecosystem capital degradation is an unpaid cost of which the counterpart is ecological debts. ENCA also allows calculating liabilities to natural capital degradation and compiling ecological balance sheets which will modify the economic decision criteria by disclosing hidden costs. The rapid development of scientific knowledge, data acquisition and information processing technologies make the implementation of ecosystem accounting possible now.

Johan Hollander's paper, entitled "Marine Organisms Response to Climate Change Effects in the Western Indian Ocean" acknowledges that global climate change is real and has anthropogenic roots, where marine species, for example, are exposed to a large array of abiotic stressors, such as warming and ocean acidification. This accelerating trend has profound effects on marine species and ecosystems, globally and the Eastern African region is no exception. The paper provides a review among ocean scientists actively studying the impact of climate change in the Western Indian Ocean. The review examines several key marine organisms and ecosystems in the region of the Western Indian Ocean, how these may be impacted by climate change, and the way forward for successful conservation and management.

A wide range of pollutions affects our oceans. The paper by Alessia Sordino on "The Importance of Sustainability for Innovative Solutions Aimed at Solving the Pollution of the Oceans," highlights three innovative and sustainable solutions capable of addressing the rapidly worsening pollution of the oceans.

Greenhouse gas emissions, plastic waste, maritime traffic and noise from deep sea mining are example of pollutants. Innovative solutions in different areas from technology, to policy, strategy system innovation and process innovation have been scientifically researched and developed. However, the concept of sustainable innovative solutions is fundamental.

5. The paper by Somya Mathur & Badri G. Narayanan, "Analysis of trade Liberalization of the Blue Economy in Indian Ocean Rim Association," attempts to capture the impact of the global trade, its input output linkages and the subsequent economic behavior in the Blue Economy. While several studies have been done on the Blue Economy, there has been none on the trade liberalization, focusing on the sectors pertaining to the Blue Economy, in Indian Ocean Rim Association, comprising of 22 Member States. This paper would further help in understanding whether the objectives of enhanced economic growth and employment opportunities can be attained through trade liberalization.

In this Special Issue of the Journal, we have the privilege to feature a report on "The Initiatives on Blue Economy by the Federation of Indian Chambers of Commerce and Industry (FICCI)." FICCI serves as the Business Secretariat of Indian Ocean Rim Association in India and has been actively pursuing the Government of India's priority agenda with IOR through a range of policy dialogues, workshops, capacity building programmes, and industry-led initiatives.

The CIOS expresses his gratitude to Dr. N. Nokwe, IORA Secretary General for her constant support and inspiration to the timely completion of the issue. We are thankful to the Editorial Board of the JIORS for their continuous dedication. With the COVID-19 pandemic, we highly value the contribution and commitment of our authors for submitting their scholarly and analytical papers, and their timely resubmission of the revised papers during these trying times. The CIOS is failing in his

duty if the hard work done by Ms Deepshikha Parmessur, Research Assistant to the CIOS, is not appreciated. She did everything perfectly and in time. My thanks also go to Mr Sun Veer Moollye for designing the JIORS and Ms Daniella Smit for uploading the JIORS.

We hope this special issue of JIORS on Blue Economy may be useful in future enhancing the undertaking of the readers. The theoretical issues raised, and outcomes of the papers will be further debated and investigated by the academicians, researchers and policy makers.

Prof V.N Attri

Editor in Chief and Managing Editor
Chair in Indian Ocean Studies
Indian Ocean Rim Association
vn.attri@iora.int

INITIAL MEASURES OF THE ECONOMIC ACTIVITY LINKED TO BANGLADESH'S OCEAN SPACE, AND IMPLICATIONS FOR THE COUNTRY'S BLUE ECONOMY POLICY OBJECTIVES

Pawan G. Patil (World Bank), John Virdin (Duke University's Nicholas Institute for Environmental Policy Solutions), Charles S. Colgan (Middlebury Institute of International Studies at Monterey), M Gulam Hussain (Bangladesh Ministry of Foreign Affairs), Pierre Failler (University of Portsmouth), and Tibor Vegh (Duke University's Nicholas Institute for Environmental Policy Solutions)¹

Abstract

The Government of Bangladesh resolved its maritime boundaries in 2014, resulting in jurisdiction over ocean space equivalent to 80 percent of the country's terrestrial area. To encourage the development of this area and the resources it contains, the Government embraced the concept of a "blue economy" in its most recent development plan, as a broad label for all ocean-linked economic activities that are environmentally and socially sustainable. To support the Government's effort to translate its blue economy aspirations into operational policies, an accounting exercise was conducted to provide initial measures of Bangladesh's oceanlinked economic activity, as a baseline by which to set targets. The results suggest the contribution of ocean-linked economic activity in Bangladesh in 2014-2015 was just over 3% of national gross value added, derived relatively evenly from tourism and recreation, capture fisheries and aquaculture, transport and energy. The Government's intention to design blue economy policies will need to be supported by extending the analysis in this study to a full ocean economy satellite account, eventually adding measures of the economic value of marine ecosystem services and the costs of environmental degradation, as well as the status of the underlying stocks of natural capital.

Introduction

With the resolution of maritime boundary disputes with Myanmar in 2012 and with India in 2014, the Government of Bangladesh has now fully defined the ocean space under its jurisdiction according to the United Nations Convention on the Law of the Sea (see Figure 1). That marine space is equivalent to 80 percent of the country's terrestrial area, and the Government prioritized its use as a key source of future economic growth (Hussain et al. 2017a, 2017b; Alam, 2014). To encourage the development of this ocean space and the resources it contains, the Government has embraced the concept of a "blue economy", as a general framework for all activities related to ocean-linked economic growth that are environmentally and socially sustainable (Patil et al. 2018).

The blue economy concept features prominently as a policy objective in the Government of Bangladesh's Seventh Five Year Plan completed in 2015 to support the country's economic development (GED 2015), and in the recently completed Bangladesh Delta Plan 2100 (Bangladesh Delta Plan 2100 [Strategy], 2018). To help deliver on this objective the Government subsequently undertook a number of technical consultations, most recently in the Second International Blue Economy Dialogue hosted by the Ministry of Foreign Affairs in late 2017. That same year the Government established a new department titled the "Blue Economy Cell", with a mandate to coordinate across sectoral ministries in order to better chart a path toward sustainable development of the ocean area, and to answer key questions about implementation of the five-year development plan (Patil et al. 2018).

However, as the Government has wrestled with implementation of its blue economy policy objectives, a number of questions have arisen, beginning with how to: (i) better measure the current economic uses of the ocean space as a baseline for decision-making, (ii) identify clear targets for sustainable growth of the use of this space,

¹ Facts and opinions published in the Journal of Indian Ocean Rim Studies (JIORS) express solely the opinions of the respective authors. This in no way represents the views of IORA. The Authors are responsible for their citing of sources and the accuracy of their references and bibliographies. The editors cannot be held responsible for any lacks or possible violations of third parties' right.

and (iii) set a policy pathway to get there. Bangladesh is not alone in facing these questions, nor in grappling with the complexities of the blue economy concept as an ocean-based economic growth model (Voyer and van Leeuwen, 2019; Voyer et al. 2018; Golden et al. 2017). In recent years, many of the world's coastal and island governments have prioritized ocean-linked growth through some form of this concept, and definitions and applications have differed significantly, often with the basic information requirements for any such approach lacking (Colgan 2017a).

To assist the Government of Bangladesh to answer these questions, the European Union (EU) provided a two-year technical assistance program in collaboration with the World Bank, from 2016 to 2018 (Patil et al. 2018). As part of that program, this study was conducted to help the Government generate initial measures of the ocean-linked economic activity in the country. These measures were known to be incomplete but were a necessary starting point. The economic accounting exercise to estimate these measures led to the identification of information gaps and suggested methods for the government to fill them, including estimating the costs of environmental degradation in the ocean and the size and distribution of the economic costs and benefits of possible development pathways. The study thus provided the Government with a partial baseline on which policy and reform pathways can be assessed and growth measured, as the country pursues its blue economy objectives. The exercise for Bangladesh also points to both issues and strategies for developing countries with more limited economic and environmental data systems to begin the process of creating empirically grounded blue economy strategies.

This map illustrates the geographical location of Bangladesh and its Exclusive Economic Zone (EEZ) in the Bay of Bengal. The map shows Bangladesh's land borders with India to the west and north, and Myanmar to the east. The Bay of Bengal is located to the south of Bangladesh. The EEZ is defined by a red line, which is labeled "200 nautical mile limit". The EEZ is shaded in light blue. The Bay of Bengal is labeled "Bay of Bengal". The map also shows the "Mouths of the Ganges" and "Straight baselines". A legend in the top right corner identifies the symbols for Bangladesh EEZ, Maritime Boundaries, National Capital (Dhaka), and International Boundaries. A scale bar in the bottom right corner shows distances in miles (0, 50, 100) and kilometers (0, 50, 100). An inset map in the bottom right corner shows the location of Bangladesh in South Asia, labeled "Area of map".

BANGLADESH EEZ

- BANGLADESH EEZ
- MARITIME BOUNDARIES
- NATIONAL CAPITAL
- INTERNATIONAL BOUNDARIES

BANGLADESH

INDIA

MYANMAR

BAY OF BENGAL

BANGLADESH EEZ

200 nautical mile limit

0 50 100 Miles

0 50 100 Kilometers

Area of map

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WORLD BANK GROUP

This map was produced by the Cartography Unit of the World Bank Group. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of the World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

Methods

Key concepts underpinning the analysis: the ocean economy in Bangladesh. At the time that it was articulated as a policy objective, the blue economy concept was relatively vaguely defined in Bangladesh. This is consistent with discourse in international policy forums on the concept, where it has been used in very different terms (Silver et al. 2015) and characterized as a “buzzword” with general agreement in the abstract but not in practice (Voyer et al. 2017, Bueger, 2015). Just a few examples of countries promoting the blue economy in different terms as part of their economic development strategies include Australia (Voyer et al. 2017); China (Conathan and Moore 2015; Zhao et al. 2014), the European Union (Suris-Reguerio et al. 2013; European Commission, 2012), India (ANI, 2017), Indonesia (Salim, 2014; Sunoto, 2014), and a number of small island developing states such as Grenada and Mauritius (Cervigni and Scandizzo, 2017; Patil et al. 2016). For purposes of this study, the definition provided by the World Bank and United Nations (2017) was used, where the blue economy refers to “the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable.”

The “blue economy” is an evolution of the concept of an “ocean economy”. The ocean economy is defined as a discrete segment of national economies and more broadly the global economy as measured by conventional economic measures such as gross domestic product and gross value added. Measuring the share of national economies linked to the ocean emerged, as countries aimed to develop more integrated ocean policies that captured economies of scale and reduced negative externalities, similar to other concepts for segments of the economy where industries are interlinked by some common feature such that they collectively function as a system rather than a fragmented list of individual sectors, e.g. the “bioeconomy” or the “information economy” (OECD, 2016; Park and Kildow, 2014). Though differently defined in many contexts, the OECD (2016) recently provided a widely used definition of the ocean economy as the sum of the economic activities of ocean-based industries,² and the assets, goods, and services of marine ecosystems (or simply ‘ecosystem assets’).³

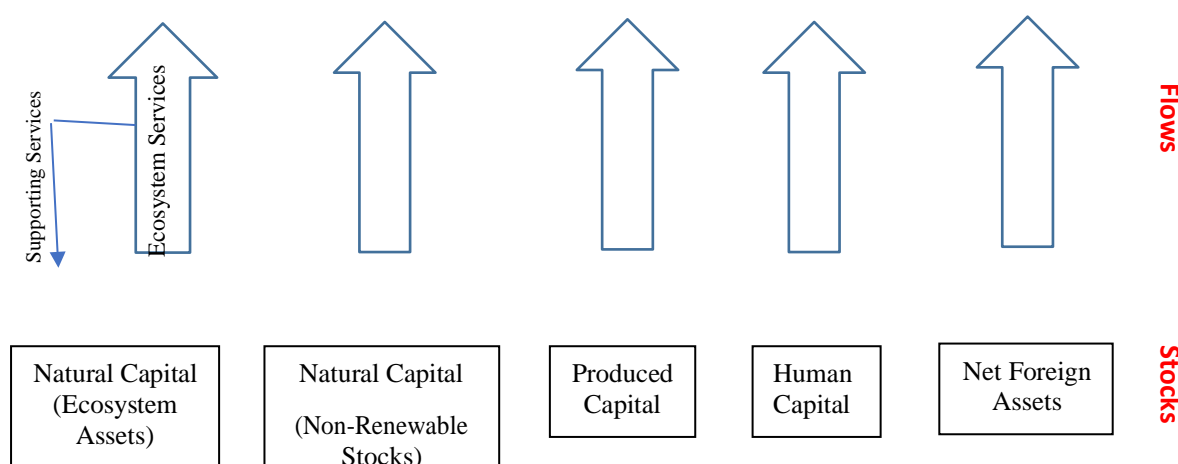
This study considered the output from those economic activities using the OECD’s definition of the ocean economy, that depend upon four classes of assets (capital), following the framework used in Lange et al. (2018): natural capital, produced capital and urban land, human capital and net foreign assets (Figure 2). The four types of capital support an ocean economy comprising several economic sectors, each including specific industries or services. Countries have included different sectors and industries based on the context, with 25 countries identifying 54 industries as part of the ocean economy for example. Despite differences, these efforts have typically identified a core group of sectors and industries in the ocean economy: living resources, marine construction, tourism and recreation, boat building and repair, marine transportation, and minerals (including oil and gas) (Colgan, 2017b).

Following Park and Kildow (2014), for operational purposes this study defined the ocean economy in Bangladesh as the sum of the economic activities of ocean-based industries that take place in areas under the Government’s jurisdiction, and the assets, goods and services of marine ecosystems in the country’s waters. As in past descriptions by the Government of Bangladesh (Alam 2014), this study characterized the country’s ocean economy as twenty-six industries and services defined in ways that align with categories defined in the United Nations International Standard Industrial Classification (ISIC) system, which is used by the Government of Bangladesh for its national income accounts. As discussed below, data availability also affected the definitions

² The term ‘industry’ embodies only market-based activities in the private and public sectors, while the term ‘economy’ captures both the values embodied in market based exchanges and the values placed on goods and services but not determined in markets (OECD 2016).

³ The term ‘ecosystems’ is used here to characterize the interaction of communities of living organisms with the abiotic environment. Ecosystems are varied both in size and, arguably, complexity, and may be nested within one another. In practice, use of the term is more intuitive than based on any distinct spatial configuration of interactions (TEEB 2010).

used. Seven sectors are identified: living resources, minerals, energy, transport and trade, tourism and recreation, carbon sequestration, and coastal protection.⁴



Sources: Based on definitions in Lange et al. (2018) and Brown et al. (2016)

Figure 2 The Four Types of Capital Underpinning the Ocean Economy

Note that ambiguity remains of what is included in the definition of the ocean economy in the country and what is not. For example, given the similarities in production technology and supply chains, as well as the influence of marine ecosystems throughout the delta, fisheries and aquaculture categorized as 'inland' by the Bangladesh Department of Fisheries (DoF) could justifiably be included in the country's definition of the ocean economy.

Measuring Bangladesh's ocean economy. On the basis of the concepts described above, this study included an accounting exercise to generate common measures of an ocean economy for the case of Bangladesh: annual economic output (e.g. the value added of each industry as its contribution to Gross Domestic Product) and total employment. Unpublished government data on the contribution of specific industries to gross value added (GVA), together with information on employment, was accessed from the Bangladesh Bureau of Statistics (BBS), and supplemented as needed to fill gaps with (in sequential order): (i) peer-reviewed literature published before August 2017, and (ii) industry reports and other gray literature. More detailed measures of annual output might include the direct (within an industry), indirect (between industries, such as supplying industries), and induced (local spending linked to direct and indirect industries) contributions of the ocean economy. However, these data were not systematically available in disaggregated form in Bangladesh, though many industries of the ocean economy are measured in aggregate by the Bangladesh Bureau of Statistics BBS (Alam 2014).

Where available, data were provided by the BBS in disaggregated form, as value added by industry. Where data were not available, the data published according to the UN System of National Accounts was also checked. However, analysis of main aggregates contained useful data for the "fisheries" sector only. In addition, the United Nations International Yearbook of Industrial Statistics was reviewed, with relevant data on number of establishments, employees, and wages for three industries: "fish processing," "ship and boat building," and "ship building." (United Nations Economic & Social Affairs 2016)

However, the most recent data available were from 2006, and were not utilized for this analysis. Subsequently, for remaining gaps the peer-reviewed literature was searched (for publications prior to August 2017) using the terms "Bangladesh" + "ocean" + "economy" + "GDP" generally, as well as searches for each

⁴. The Government of Bangladesh has characterized the industries/services of the country's ocean economy as occurring within six sectors: fisheries, maritime trade and shipping, energy, tourism, coastal protection/artificial islands/greening coastal belts, and maritime monitoring, surveillance and spatial planning (Alam 2015; GED 2015).

ocean economy and related industry and service using the following format: “Bangladesh” + “[name of ocean economy industry/service]”+ “[GDP/income/value added]”. These searches did not yield additional data beyond government statistics referenced previously.

A number of gray literature sources proved useful, notably an economic valuation of the marine and coastal ecosystem services in the Bay of Bengal, produced as part of the Bay of Bengal Large Marine Ecosystem (BOBLME) project. (Emerton 2014) Similarly, industry reports and other gray literature sources provided data on fisheries, aquaculture, ship building, ship breaking, tourism, and recreational fisheries.

The resulting estimates of GVA are coarse and should be indicative of only the order of magnitude of the annual output from Bangladesh’s ocean economy, given their reliance on heterogeneous data sources. Of note, these estimates of GVA provide only a partial baseline of the size of Bangladesh’s ocean economy, for several reasons: (i) the measures of economic output are incomplete in that they exclude (a) industries such as any marine-related construction, recreational fisheries, coastal and maritime research and education, and maritime safety and security; and (b) a number of ecosystem services that lack market transactions but which may constitute a significant portion of the ocean economy ; (ii) the measures do not subtract the costs to the country from environmental degradation resulting from various activities in the ocean economy, that is, externalities to the ocean economy such as pollution from ship breaking; and (iii) the measures reflect a very ambiguous distinction between activities considered to be ocean-related and not ocean-related due to Bangladesh’s geography, which is dominated in large part by the estuary and delta of the multiple rivers flowing south through Bangladesh.

Results: Baseline Measures of Bangladesh’s Ocean Economy

Table 1. Annual Gross Value Added from Bangladesh’s Ocean Economy (Nominal US\$ mm)

Ocean Economy Sector	Ocean Economy Industry/Service	ISIC Code [1]	2009-10 [2]	2010-11	2011-12	2012-13	2013-14	2014-15	Employment
Living Resources	Marine capture fisheries	311	664	777	786.23	907.49	1,037.49	1,167.79	1.35 mm [3]
	Marine aquaculture	322	78.65	92.48	99.76	122.05	144.99	163.2	
	Shellfish Aquaculture								
	Fish processing and retailing	311	0.19	0.22	0.21	0.19	0.18	0.17	
Minerals	Sea salt production	893	123.2	124.11	145.51	184.35	195.45	197.88	5.00 mm [4]
Energy	Offshore gas and oil:	0610, 0620	993.55 :	972.26:	943.63:	1,011.41 :	1,068.27 :	1,205.14 :	
	Crude petroleum		22.42	23.65	23.69	25.16	26.4	30.55	
	Natural gas		971.13	948.62	919.94	986.25	1,041.87	1,174.58	

Transport and Trade	Transport		1,030.46:	1,082.11:	1,038.04:	1,108.79:	1,220.21:	1,366.10:	
	Maritime freight transportation	5222	307.90	319.55	295.81	300.33	327.15	375.58	
	Maritime passenger transportation		617.61	659.27	606.66	663.14	720.69	788.35	
	Port and harbor operations		104.95	103.29	135.57	145.32	172.37	202.17	
	Ship and boat building/breaking	3011,	237.71:	245.57:	240.95:	246.41:	246.90:	525.27:	
	Ship building and repair	3315, 3830	110.32	114.77	106.68	109.58	108.59	387.06	
	Ship breaking[5]		127.39	130.80	134.27	136.83	138.31	138.21	1.00 mm
Tourism and Recreation	Coastal and maritime tourism [6]		901.39	819.16	967.76	1,038.64	1,379.96	1,567.43	
Carbon Sequestration	Blue carbon	N/A	A market does not exist for the flow of benefits generated from sequestration of additional stocks of carbon.						
Coastal Protection	Habitat protection, restoration	N/A	A market does not exist for the flow of protection benefits provided by natural habitats as resource stocks. US\$663 million has been estimated using benefit transfer and proxy estimates for the storm protection defenses of a hectare of mangrove forest in the Bay of Bengal region.						
Total Ocean Economy GVA [7]			4,751.41	4,084.34	4,222.09	4,619.33	5,293.45	6,192.98	
Bangladesh GVA [8]			110,046.00	122,120.00	126,250.00	142,783.00	164,758.00	186,042.00	
Taxes-Subsidies			5,239.00	6,561.00	7,152.00	7,214.00	8,128.00	9,117.00	
Bangladesh GDP			115,285.00	128,681.00	133,402.00	149,997.00	172,886.00	195,159.00	
Ocean Economy GVA as a % of Bangladesh GVA			4.31%	3.35%	3.34%	3.24%	3.21%	3.33%	

NOTES

[1] International Standard Industrial Classification

[2] Gross Value Added by industry available for fiscal years

[3] Data is often aggregated with inland fisheries and aquaculture. Total estimates range as high as 17.8 million in 2014, of which marine capture fisheries and aquaculture were 1.35 million.

[4] Direct employment; 25 million indirect estimated

[5] Data on ship breaking is not available at BBS. Based on Hossain (2015), estimates ass gross value added of US\$0.92 million, multiplied by 150 large ships dismantled per year.

[6] Satellite accounts for tourism are not available at BBS, so data is aggregated for the entire country. The estimate assumes that 16% of gross value added from tourism is coastal and marine-related.

[7] Exchange rates used: 2009/2010 – 69.18 Taka per US\$; 2010/2011 – 71.17 Taka per US\$; 2011/2012 – 79.1 Taka/US\$; 2012/2013 – 79.93 Taka/US\$; 2013/2014 – 77.72 Taka per US\$; 2014/2015 – 77.67 Taka per US\$

[8] GVA and GDP amounts given for the second year in the period, e.g. for “2009-2010”, the GVA given is for 2010, as GVA and GDP are recorded annually by calendar year.

Sources: unpublished BBS statistics, World Bank; supplemented with: DoF (2017); Failler et al. (2017); UNSNA (2017); EIA (2017); Shamsuzzaman et al. (2017); Dausendschoen (2016); Meisner et al. (2016) Hossain (2015); WTTC (2016); FAO (2014, 2016); Al Mamum et al. (2014); Kabir (2016); Sea Around Us Project (2017); Emerton (2014); Alam (2014)

Table 1 summarizes the GVA to the Bangladesh economy from ocean activity in recent years. GVA is used as a measure here for an entity smaller than the whole economy, rather than GDP (for reference, GDP is calculated as GVA plus taxes minus subsidies in each sector). These measures indicate only the order of magnitude of the output from the ocean economy, given their reliance on heterogeneous data sources. Each industry's value added does not equate to its contribution to GDP, since the latter includes the gross value added plus product taxes minus subsidies not already included.

The gross value added shown in Table 1 is derived relatively evenly from tourism and recreation, marine capture fisheries and marine aquaculture, transport and energy (Figure 3).

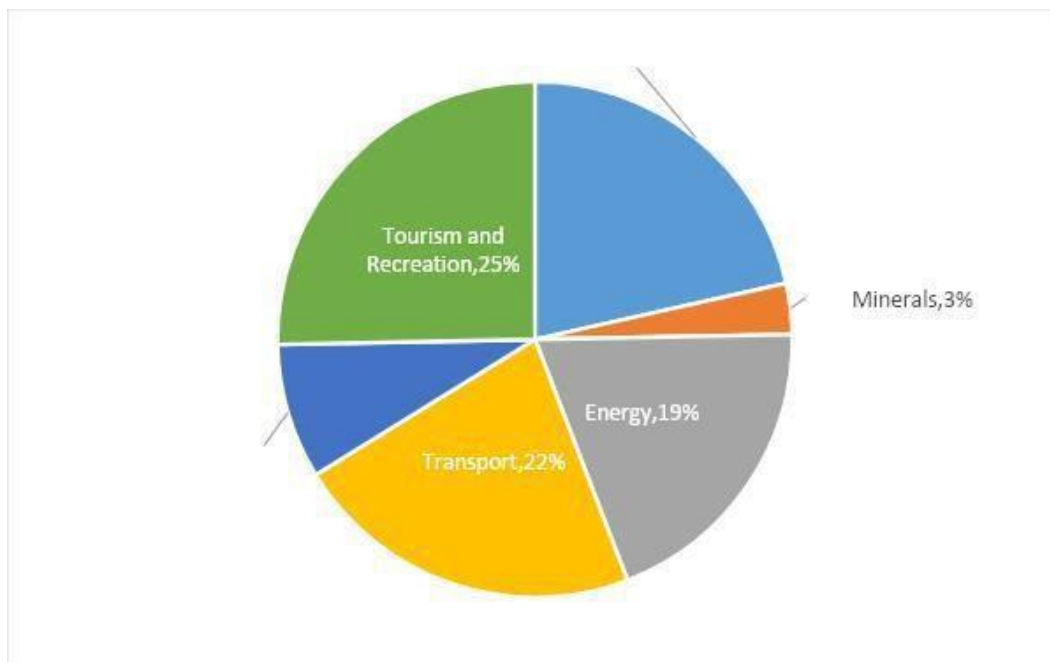


Figure 3. Composition of Ocean Economy in Bangladesh, % of gross value added (2014-2015)

Discussion

Although incomplete, the estimates in Table 1 provide a baseline measure of the ocean economy in Bangladesh, equivalent to just over 3% of the economy in the 2014-2015 fiscal year, as a starting point for the Government to set targets for the country's blue economy aspirations. However, this baseline is incomplete because: (i) the measures of output do not include a number of ecosystem services that are not traded in markets but which may be significant (e.g. the carbon sequestration and coastal protection services of the country's mangroves); and (ii) the measures do not subtract the costs to the country from environmental degradation resulting from various activities in the ocean economy, for example pollution from ship-breaking. Quantitative measurement of marine ecosystem services as an economic value is a relatively new research field, however without such estimates, measures of output from the ocean economy will always be incomplete (OECD 2016). Finally, it should be noted that these measures of annual economic output provide a snapshot in time, but do not reflect sustainability or the status of the underlying capital stocks, e.g. natural capital assets such as fish stocks (Lange et al., 2018).

With these caveats in mind, the benefits of beginning to measure the economic activity connected to the ocean space and ecosystems under Bangladesh's jurisdiction is that these industries and ecosystem services do not develop in isolation. Rather, they interact as a system with a common denominator: the fluid, buoyant, three-dimensional environment of the ocean (OECD 2016). Analyses such as those conducted in this study can raise the awareness of policy-makers to the relative importance of ocean industries and services and shape a coherent approach to their development and use. Resulting benefits include lower costs from shared common infrastructure, cross-fertilization of technologies and innovation, reduced impact on the ocean environment, and more effective use of ocean space (Colgan, 2017a; OECD 2016)

Despite the potential benefits for Bangladesh to develop a more coherent and strategic approach to sustainable development of its ocean economy, an overarching policy framework and integrated planning process are not yet in place, nor measurable targets and consistent monitoring of progress. Even collecting basic data on economic output from industries included in the definition of the ocean economy is labor intensive and difficult. Hence a first step in the policy process would be to enhance measurement of the ocean economy to feed into

policy-making, beginning with regular collection of basic output measures such as shown in Table 1. Currently in Bangladesh, the data on the gross value added of ocean industries/services with markets is not disaggregated in the national accounts (constructed by collecting administrative data from different public and private agencies and BBS census surveys), and hence only available through significant effort. This could be achieved by developing an “ocean account” at BBS, beginning with steps to: (i) identify the country’s ocean economy industries at appropriate levels of precision (in some cases in more detail than the ISIC codes as shown in Table 1); and (ii) include a geographic measure of proximity to the ocean and coast for these industries.

A second step in the process could be to articulate a range of policy scenarios for development of the country’s ocean economy, building upon the initial assessment of the size and scope of this segment of the national economy provided in Table 1 as a baseline, together with the summary of information available on the status of the underlying natural capital assets. On this basis, various scenarios of growth in Bangladesh’s ocean economy could be analyzed through use of existing forecasting models (at least for selected sectors), taking into account what is known about the various external drivers. The output from modeling these scenarios would be estimates of the costs and benefits to Bangladesh from different development pathways for the ocean economy (e.g. including one or more ‘blue economy pathways’), from which to prepare specific policies needed to get there. As a starting point, priority sectors in a ‘blue economy’ pathway such as capture fisheries may be a priority for such scenario modeling, estimating the economic benefits and upside to investment in resource management and rebuilding depleted fish stocks (accompanying benefits from enhanced food security).

With these steps, it is possible to begin to operationalize its blue economy aspirations, by measuring where this segment of the economy is today, and targets for where it possibly could be over time, given a number of policy reforms and investment. Bangladesh could become one of the first countries to make concrete progress from broad aspirations to tangible policies and measurable outcomes of progress in the transition to a blue economy.

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TOWARDS ECOLOGICAL GOVERNANCE BASED ON ECOSYSTEM NATURAL CAPITAL ACCOUNTING

Jean-Louis Weber

Former Special Advisor to the European Environment Agency for Environmental Accounting

Associate Researcher at the Ecole Normale Supérieure de Lyon, France

Author of the CBD's Technical Series 77 on "Ecosystem Natural Capital Accounting: A Quick Start Package"⁵

Abstract

The ignorance of ecosystem degradation is largely since it broadly escapes the economic calculation on which most decisions are made. In fact, while material natural resources are appropriable and exploitable as economic assets and therefore accounted for, the reproductive functions of the natural systems that provide them are public goods. These functions are considered as "externalities" by the standard economic theory and are not recorded in accounting books so far as their degradation doesn't generate costs for the owner. Yet there is a cost regarding ecosystem functions as public goods, from which by definition no one can be denied access. Discussions are now on the appropriate metrics needed for addressing biodiversity issues on par with climate change budgets and accounts.

The Ecosystem Natural Capital Accounting – Quick Start Package (ENCA-QSP) published by the UN CBD in 2014 is an enlargement of the UN System of Economic-Environmental Accounting, of indicators frameworks that focus on the measurement of ecosystem services as well as of the "carbon" accounts on which are based UNFCCC mechanisms. The ENCA methodology is an accounting framework which addresses all ecosystems (inland as well marine and the atmosphere systems) and being based on spatially explicit data and statistics, it can be implemented at any scale, by socio-ecological geographical units as well as for countries, local governments and enterprises.

ENCA allows calculating liabilities to natural capital degradation and compiling ecological balance sheets which will modify the economic decision criteria by disclosing hidden costs. Ecosystem capital degradation is an unpaid cost of which the counterpart is ecological debts. These debts remain virtual as long as they are not measured and recorded in order to be offset. Accumulation of debts, however, is a risk that can manifest itself in slow or brutal catastrophic crises of technological, climatic, ecosystem or/and financial nature. In a first step, ecosystem assets, degradation and debts are recorded in ENCA using a special currency for measuring ecological value. Accounts of ecological values can be used for auditing by the government as well as by financial rating agencies and institutions. The rapid development of scientific knowledge, data acquisition and information processing technologies make the implementation of ecosystem accounting possible now.

⁵ Facts and opinions published in the Journal of Indian Ocean Rim Studies (JIOS) express solely the opinions of the respective authors. This in no way represents the views of IORA. The Authors are responsible for their citing of sources and the accuracy of their references and bibliographies. The editors cannot be held responsible for any lacks or possible violations of third parties' right.

Introduction

Our neglect of the natural systems that directly and indirectly provide for our livelihoods results in the depletion of material resources and in the alteration of the ecosystem functions that permit their renewal, and consequently, of our life on Earth. This finding is renewed year after year, through warnings from the IPCC on climate, from the Global Footprint Network on the inexorable progress of the day of surpassing the maximum use of natural resources and from the WWF and IUCN on the collapse of biodiversity. But few consequences are drawn from these observations and the usual policies' "small steps" finally hide the magnitude of the challenge that we face.

The ignorance of ecosystem degradation is largely due to the fact that it escapes the economic calculation on which most decisions are made. In fact, while material natural resources are appropriable and exploitable as economic assets and therefore accounted for, the reproductive functions of the natural systems that provide them are public goods. These functions are considered as "externalities" by the standard economic theory and are not recorded in accounting books so far as their degradation doesn't generate costs for the owner. Yet there is a cost regarding ecosystem functions as public goods, from which by definition no one can be denied access. Awareness of this issue is rising with a strong focus on climate change.

Global warming has become a major concern for governments, citizens and more and more businesses, especially financial companies, which perceive the scale of the risks that may result for investors. In comparison, the collapse of biodiversity and more generally of the biosphere appears as a minor subject, whatever the importance of alarm warnings from everywhere, recently synthesized in the 2019 IPBES report⁶. For the climate, an objective is defined on the basis of the relationship between atmosphere's average temperature and concentration of greenhouse gases, and actions are taken to limit the latter by reducing net emissions. These policies and actions are based on accounts of pledges and achievements of countries and companies, often called "*carbon accounting*". Nothing like that exists for biodiversity for which invoked the complexity of things and the lack of metrics on which integrated policies could be based.

This situation is untenable for at least two reasons. The first one is that **climate warming** is not due to the sole effect of greenhouse gas emissions but just as much to the rapid **degradation of the biosphere** due to its frantic exploitation. The biosphere itself is the main climate regulator, beyond carbon sequestration. It has played this role at the global level for 500 million years, as well as at the regional level where forests are an essential element in the regulation of the water cycle. The second reason is that "*Partial solutions to problems in complex social-ecological systems do not work for very long.*"⁷ "*Partial solutions*" may even have negative feed-back impacts as indicated, for example, by the IPBES report that warns against the perverse effects of carbon sequestration policies through intensive plantations that threaten biodiversity (one might add the water cycle and the living space of fragile populations). This does not mean that we should not reduce the atmospheric GHGs and other pollutants and try to restore ecosystems where it is still possible. It means that it must be done with respect to the biosphere's integrity and self-regulating capacity. In other words, if we fail in stopping the depredation of the terrestrial and marine biosphere and its degradation by pollutions, the policy of reducing CO₂ emissions may not have the desired effects.

The need to integrate biodiversity into all socio-economic practices has been expressed since several years in the context of the UN Convention on Biological Diversity (CBD) through an approach based on ecosystems that includes humans. In 2010 the CBD COP 10 adopted the Aichi Strategy which states in its Objective 2 that: "*By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.*" This objective has been included in the **Sustainable Development Goals** (Target 15.9). To support the integration of biodiversity into accounting schemes, the CBD has

⁶ Report of the Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on the work of its seventh session, IPBES/7/10/, May 2019

⁷ Walker, B., 2005: *A Resilience Approach to Integrated Assessment*, IAJ, Vol. 5, Iss. 1 (2005), Pg. 78

published in 2014 a manual entitled “*Ecosystem Natural Capital Accounts: A Quick Start Package*” (ENCA-QSP)⁸.

Why accounting for ecosystems?

Need for supplementing current policy responses to ecosystem degradation

Current policy responses to ecosystem degradation are firstly based on regulations to limit or forbid the use of chemicals in order to avoid toxic pollutants and protect public health, to protect high nature value areas, to restrict natural resource use to preserve stocks from depletion (in particular water, timber and fish stocks, as well as wild game).

Command and control policies have been supplemented by the use of economic instruments in order to correct market prices when they don't account for external costs related to environmental degradation. They are fees for financing water and air pollution abatement and managing solid waste, and other fees for limiting resource use. Taxation of resource use is progressively expanding to other environmental issues, as for example shown by attempts to implement “carbon” taxes for the sake of Greenhouse Gas emissions mitigation.

Symmetrically, economic incentives to good practices, including subsidies are provided by governments to support technological transitions towards less destructive consumption patterns. Can be mentioned here the encouragement to the banking system to favor investments less harmful to the environment and the transition to a more sustainable economy, known as “green finance”.

These policies are much needed but they are insufficient internalization of externalities as they remain to some extent external to the economy. They are perceived by economic agents as external constraints, and therefore opposed with the consequence that they cannot reach the level required by a situation of fast degradation of the climate system and of the biosphere. Arguments used relate to the economic competition, fierce at the global level in the context of a very slow economic growth, and the need to secure income and employment in countries.

Accounting for ecosystem degradation would offer new levers for action as all economic actors would have comprehensive information on their own situation and the possibility to make their decisions accordingly. This information would allow calculating the real costs borne by economic decisions as well as the benefits relating to new opportunities open by transitions toward sustainability and, oppositely, by the risks (including financial risks) of not meeting societal targets.

While conventional measures impose various constraints on producers' decisions, recording ecosystem degradation and depreciation sets only one overall target which can be stated as “no net ecosystem capital degradation”. It is then up to the producers to make their own economic choices regarding their stated and measured liability to the public good. Incorporating ecosystem depreciation into accounts, hence calculating the complete price of consumption would change not simply the level of production but its structure towards utilities requiring less input from Nature (less natural capital consumption).

For being operational, such accounting must go beyond the pioneering endeavors by many companies of self-assessment and disclosure of caused environmental impacts. This ethical approach is very valuable and stimulates important reflection on the way things could be done. But it is not likely to be enough in the context

⁸ CBD, 2014, *Ecosystem Natural Capital Accounts: A Quick Start Package*, CBD Technical Series 77, Montreal (drafted by Jean-Louis Weber).

of the global economic competition. What is needed is, as for the other accounting variables, ecosystem physical degradation and subsequent depreciation are incorporated into accounting standards: international financial accounting standards (for companies) and the UN System of National Accounts (for countries). Accounting standards are required for comparisons, trends analysis, and verification.

What conventional accounts do not consider?

The accounting representations of the economy on which the practices of all the private and public actors are based as much as, to a large extent, the prevailing economic theory, are indicative of the denial of taking nature into account. Both the accounting standards of companies and the national accounts describe the economy as a closed system, trading with its environment only through the exploitation of natural resources integrated into the economy because of their appropriation and evaluated from the point of view of monetary benefits alone. The depletion over time of the main material resources (subsurface resources, timber stocks, fish stocks) is well recorded by the companies' accounts as a deferred consumption of capital and thus amortized. By contrast, the degradation of natural systems resulting from economic activity is not reflected in companies' accounting results.

National accounts do not record either depletion or degradation of natural resources. In the flow accounts and thus in the calculation of GDP and National Income, clear felling a forest to make it agricultural land is registered positively twice, as the sum of two productions: of "*timber*" product and of creation of agricultural infrastructure. The loss of productive (timber) and reproductive (forest and all dependent services) functions is simply ignored.

It is however admitted that fair accounting⁹ (about shareholders, the Stock Exchange, the Fiscal, the Parliament, the citizens ...) must take into account exhaustively all the revenues and all the costs. Otherwise, the accounting result (profit or loss, income, product, assets ...) is incorrect and may even be suspected of falsification.

A particularly important element of fair calculation is the recording of the consumption of capital goods. While the intermediate and final consumption are recorded as destructions taking place during the financial year, the consumption of capital spreads out over several periods (years) between which it must be distributed according to agreed rules (under the attentive control of the auditors of the enterprise and the tax authorities) for the calculation of the net profit. This is called **depreciation** of assets in business accounting and **consumption of fixed capital** in the national accounts.

Economic performance assessment is not limited to commenting accounts but somewhat relies heavily on the analysis of accounting results. As a result, the accounts feed into models, ratings and assessments on which policy makers base their choices. Hence, accounts framing appears to be an essential element in the appropriation of stakes by the actors and in this context, **what is not accounted for acquires an accessory character**.

Ecosystem and biodiversity values are not properly recorded in accounting books because accounting standards are based on property rights of institutional units. The System of National Accounts is very explicit in its definition of assets: "*Assets as defined in the SNA are entities that must be owned by some unit, or units, and from which economic benefits are derived by their owner(s) by holding or using them over a period of time.*"¹⁰ Assets are owned by private institutions or persons or on behalf of the community by government units.

Ecosystems are at the same time owned assets and public goods. Owned economic natural resources, assets and services are properties that can be exploited for production of crops, timber, fish... But ecosystems are cycling and living systems which have the capacity to renew according to their structure and functions,

⁹ In French, the expression used refers to sincerity. The use of both fairness and sincerity mean that the issue is not a purely technical one, but relates to fraud as well.

¹⁰ See SNA 2008, para 1.48, page 65. United Nations (2009), System of National Accounts 2008, ISBN 978-92-1-161522-7 <http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf>,

integrity, health, resilience, biodiversity... This capacity is that of public goods in the economic sense, goods which use is “non-rival” (everybody can access them) and “non-exclusive” (nobody can be deprived of them)¹¹.

For the economy, public goods are external. They are external to accounting books; they are not owned and therefore their depreciation is not part of the depreciation of owned assets. Only resource depletion can be recorded as depreciation in financial accounting standards for sub-soil, timber and fish stocks. Depletion of natural resources is not even recorded in the UN System of National Accounts 2008! When public goods are degraded, no economic loss is recorded in the flows accounts from which are derived GDP and National Income aggregates. It is only recorded in an adjustment at the bottom of the economic balance-sheet under the vague category of “other change of volume of non-financial assets”.

It reminds of a statement by the Norwegian Minister of Environment at CBD COP10 in Aichi-Nagoya, 2010, who said that “*For the economy, profits are private, and costs are public*”.

Accounting for what?

Environmental accounting

Accounting for natural resources the environment is not new. In recent times, various attempts were undertaken under the names of natural resource accounts (in Norway), natural patrimony accounts (in France and Spain in the 1980s-90s), material balance (steered by the OECD and Eurostat), ecosystem services assessment (the Millennium Ecosystem Assessment and TEEB) and, the environment-economy accounts (UN System of Environmental-Economic Accounting - SEEA) ¹².

In 1993, the UN Statistical Division published a Handbook of Environmental and Integrated Economic Accounting (SEEA, 1993) commonly referred as “system of economic and environmental accounting”. The drafting of this handbook involved other agencies such as UNEP, the World Bank, OECD or the European Commission Statistical Office (Eurostat). It took stock of work carried out in countries since the mid-1970s by public agencies (mostly national statistical offices) and research institutes such as the World Resource Institute. Because of difficulties in implementation, the SEEA 1993 was revised and a SEEA 2003 issued with more practical guidelines. In 2008, the newly created UN Committee of experts on Environmental-Economic Accounting (UNCEE) decided to raise the parts of the SEEA for which sufficient experience exists up to the level of an international statistical standard. During the process of revision, the need for progress on ecosystem accounting resulted in the drafting of a second volume on the subject. The SEEA Central Framework was issued in 2012 and the SEEA Experimental Ecosystem Accounting in 2013.

In 2012, the UN Statistical Commission adopted an international statistical standard called SEEA-CF for “System of Environmental-Economic Accounting Central Framework” (SEEA 2012 -CF, 2014). As a statistical standard the SEEA-CF is proposed to national statistical offices for implementation.

Their common point is that these approaches do not provide the methodology for integrating ecosystem degradation into accounting standards. It is not enough to know how much one consumes of this or that resource, it is necessary to know if it is sustainable in time. This implies considering the problem not only from the point of view of the economy but also from the point of view of the ecosystems, taking into account just as much their extent, their volume and their productivity as their state of health which determines their robustness and their resilience.

Accounting for the natural capital

For the reasons presented above, a second volume of the SEEA has been devoted to supporting a research

¹¹ In that sense, public goods differ from common goods as the later are “non-rival” but “exclusive” as long as what has been harvested by one is no more available for anyone else.

¹² Weber, J.-L., 2018, *Environmental Accounting*, Oxford Research Encyclopedias, <http://environmentalscience.oxfordre.com/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-105?rskey=72ewQy&result=42>

agenda and the development of tests in voluntary countries. Experiments of the SEEA-EEA are developing at the initiative of the UN Statistical Division (ANCA, NCA&VES), the World Bank (WAVES), UNEP (VANTAGE, ProEcoServ) or the CBD (ENCA-QSP).

Two main approaches are presently developed: one targets ecosystem services, their benefits and the monetary value of the natural capital; the other one targets the measurement of ecosystem capital degradation in physical terms and ultimately capital depreciation in money.

Accounting for ecosystem services, their benefits and the monetary value of the natural capital

Accounting for natural capital economic benefits is an approach based on the theory of ecosystem services proposed by De Groot and Costanza and exemplified in the 2005 Millennium Ecosystems Assessment. The purpose is to highlight the value provided by the ecosystems and the loss resulting from their degradation. Ecosystem degradation equals their loss of ecosystem services. As long as ecosystem services are measured with a variety of measurement units, they are impossible to aggregate in physical terms and the solution has been proposed of their systematic valuation in money, in line with the principles of the standard welfare economics theory.

The approach meets the stream of thought around the multiple capitals vision of the economic system, which distinguish and add-up produced capital, human capital, social capital and the natural capital and calculates Total Capital (World Bank) or Inclusive Capital (Dasgupta, UNU). Total or inclusive capital is computed (with variants) alongside the “standard” capital model on the basis of the services provided by the various forms of capital. This model, a version of which is used by companies to calculate their “fair value” consists in discounting the net present value of expected income. It is clearly a utilitarian approach which explicitly acknowledges the substitutability of capital types, hence the weak sustainability target regarding natural capital.

Ecosystem capital approach through valuation of ecosystem services is dominant in WAVES applications. After some hesitations, the SEEA-EEA experimentations seem to follow the same way with bundles of services used to measure ecosystem capacity. These services are valued in money for the purpose of aggregation. Ecosystem capacity can be degraded by physical ecosystem loss in extent and condition. Finally, ecosystem services value is used for computing ecosystems value in monetary terms.

The conservation (or increase) of the net income flow and total economic wealth is called the “weak sustainability” as it considers only monetary values with the explicit or implicit assumption of the broad or total substitutability of the assets which compose the “total” capital which supports development: produced, human and natural. The concept of total capital has been in particular developed by John Hartwick (Hartwick, 1978) who established that an economy on a given growth path would remain on this path if “total” capital is maintained. This theorem was interpreted later as a condition for sustainable development, in its weak form as it didn’t require maintaining each of its components, in particular the natural capital. This is formulated in the clearest way in the Inclusive wealth report (UNU-IHDP, 2012): *“The inclusive wealth framework allows substitution across the different forms of capital and refrains from asserting any specific interest of any particular constituency. Therefore, natural capital is not preserved for its own sake, but for its contribution to the overall productive base of a country. For example, a country with extensive commercially available forest stocks will, according to the inclusive wealth measure, be able to convert some of these forest stocks to other forms of capital assets that it might need to increase the well-being of its citizens and to maintain a sustainable path. The degree of substitutability is determined by the ratio of the shadow prices of the capitals in question.”* As a consequence, environmental accounting for nature and ecosystem services in monetary units is considered to involve the acceptance of a broad substitutability between natural and other capitals, and the weak sustainability paradigm.

Accounting for ecosystem capital degradation and depreciation

Accounting for ecosystems in physical terms has its origin in works at the European Environment Agency (EEA) on “Land and Ecosystem Accounts” and “Ecosystem Capital Accounts”. Building up on early research in France, Spain, and Canada and in the UN ECE and Eurostat contexts, the EEA has made use of the newly updated land cover maps of Europe to elaborate a genuine ecosystem accounting approach based on geographical information¹³. In 2014, the EEA supported the publication of the CBD ENCA Quick Start Package. Presently, the EEA is involved with Eurostat, the Joint Research Center and the DG Environment of the EC in the Knowledge & Information Partnership for Integrated Natural Capital Accounting (KIP INCA) project.

In the ENCA approach, ecosystems are considered as a capital which should follow the general rules regarding reporting on capital depreciation. Capital goods last several years. In financial accounting standards, *depreciation* is the way to estimate an annual consumption of capital in view of making provisions for replacement at the end of life. The equivalent in National Accounting is called Consumption of Fixed Capital. Important point is that both depreciation and consumption of fixed capital are deducted from revenues to calculate the real income. In both cases, the estimations are based on assets values that are themselves estimated regarding the production that can generate. Consumption Ecosystem Capital (CEC in physical terms) and Ecosystem Capital Depreciation (ECD in monetary terms) happen when physical degradation is the result of inappropriate ecosystem (productive) use. Ecosystems are recorded in accounting books only as far as they are economic assets that contribute to production: growth of crops, growth of timber assets... Beyond that, their broader reproductive functions are not reported; therefore, their degradation is not reflected in current accounting standards. In ENCA, ecosystem capital degradation is measured in physical terms. This measurement is the main objective of the ENCA *Quick Start Package*. The next step is the assessment of physical ecosystem capital degradation by economic sectors and agents, on the basis of which ecosystem capital depreciation will be measured in money by restoration costs needed to offset physical degradation, where it happens or if it is not possible, in another place (compensation, mitigation). Hence, as the decisive factor is physical ecosystem maintenance and not the payments done for that purpose, ENCA is a tool for *strong sustainability* policies.

Accounting for weak or strong sustainability

The distinction between the paradigms of *weak and strong sustainability* refers to possibilities of substitutability between the various forms of capital: produced/financial, human/social, natural...

In the case of weak sustainability, the target is the maintenance of the total or inclusive capital. Therefore, loss of natural capital can be offset by gains of other forms of capital. In the case of strong sustainability, each type of capital should be maintained. Substitutions in that case are still possible within a given type. Ecosystem capital strong sustainability is (can only be) that of systems (with their self-regulatory capacity, their feedback loops, their resilience ...). The sustainability of variables taken in isolation can only be a weak sustainability because it allows compensation to the detriment of the resilience of the systems, or even the systems themselves (typically the inclusive monetary value ...). ENCA is a system approach and explicitly refers to strong sustainability.

Strong ecosystem capital sustainability does not mean that we must stop doing everything or that we refer to a theoretical climax (and without the man ...), which would make little sense. Strong sustainability in ENCA is understood as maintaining the *critical natural capital*. Here again, it is not a question of conserving ecosystems as they are (they have been changing for hundreds of millions of years and they will continue doing so) but of

¹³ Haines-Young, R. and Weber J.-L., *Land accounts for Europe 1990–2000, Towards integrated land and ecosystem accounting*, EEA Report No 11/2006 (EN) http://www.eea.europa.eu/publications/eea_report_2006_11

and

Weber J.-L., *An experimental framework for ecosystem capital accounting in Europe*, EEA Technical report No 13/2011 (EN) <http://www.eea.europa.eu/publications/an-experimental-framework-for-ecosystem>

maintaining their global potential (their *capability*) to reproduce themselves over time. This potential (or *capability*) is measured in ENCA by a conventional composite unit, the ECU (for Ecosystem Capability Unit) which is a quasi-currency and a metrics for quantifying the ecological value.

ENCA refers to the societal goal of *no net ecosystem degradation*. Note that this echoes the goal of the “Land Degradation Neutral Development” target of the UN Convention to Combat Desertification, the difference being that the UNCCD does not include water and biodiversity in its metrics. In ENCA, *net degradation* means: degradation *less* restoration of damage previously caused by the activity, *less* ecological value creation (which is either the fact of nature itself if left alone or a co-creation when one facilitates the restart of ecosystems). There is thus with ENCA the possibility of compensations, but not of anything: compensation of the ecological value measured in ECU.

We must clearly distinguish here the objective and the means. Actions on variables (including carbon) and on the corresponding monetary costs are means. Offsetting occurs if the means have been used to restore (or improve) the ecosystem-based capability measured with the ECU currency that combines altogether variables on carbon, water and system integrity / biodiversity. ENCA accounting in ECU is primarily an accounting of socio-ecological systems defined in practice as observable geographical units. Important point is that ENCA can be implemented at any scale, from the planetary to the national, local and even to the farm parcel ... These are the chapters 1 to 8 of the manual CBD TS77. Chapter 9 addresses the issue of ecological balance-sheet, i.e. the return to conventional national and corporate accounting.

Ecosystem accounting for/by institutional units

Institutional units' contribution to physical ecosystem degradation

ENCA is primarily established for ecosystems, which are the entities for which degradation can be assessed. Action requires shifting from the geographical to the institutional perspective. Indeed, conventional corporate as well as national accounts are established for/by institutional units endowed with the legal personality and in particular property rights. This is the purpose of the ecological balance-sheet.

Statistically, for the national accounts, ecological balance-sheets by economic sectors are feasible centrally provided that socio-economic statistics are sufficiently detailed and spatialized (in particular to detect the production resulting from degraded ecosystems). For the micro level, two cases are to be distinguished. Firstly, there are institutional units such as municipalities, natural parks, and also farms or forests estates which are mappable. In this case, the ENCA methodology can be implemented “as usual” as long as the requested detailed data are available (including very high resolution satellites for verification...) One can add in this category the environmental impact studies of territorial development projects. In practice, things are more complicated because of the need to account to direct and indirect degradation impacts. Indeed, because of the product's life cycle and of economic exchanges, impacts can be generated in other economic units (or countries) and embodied into enterprises' own products. This issue is addressed in the so-called “footprint” accounting developed in recent years: “carbon footprint”, “water footprint”, “ecological footprint”. Therefore, only a part of the data need can be derived from the spatial information system on the ecosystems; another part must be provided by statistical analysis of degradation embedded in trade flows.

For the institutional units themselves (in particular the companies), those that implement the current financial accounting standards, the rationale corresponds to the distinction between enterprise's assets used for production and the capital which is a debt to its owners¹⁴. In addition to assets' counterparts, the ecosystem capital includes an element which is not a debt to any owner or shareholders, as it is not owned, being public good: ecosystem condition and resilience (soil fertility, biodiversity, reproductive functions...). When the ecosystem capital is maintained, it can be given back in full; when it is not maintained, there is a default. In the

¹⁴ Rambaud A. and Richard J., 2015, *The “Triple Depreciation Line” instead of the “Triple Bottom*

Line”: Towards a genuine integrated reporting, in *Critical Perspectives on Accounting*, 33 (2015) 92–116, Elsevier

perspective of responsibility to the use of the public good, this degradation should be recorded in financial accounts as natural capital depreciation adding up to financial capital depreciation. This depreciation should be then offset by restoration costs. Important to note is that there is no need to assess the full monetary value of the natural capital, only to measure ecosystem degradation in physical terms and evaluate restoration costs. As for the statistical level, there is a need to record indirect degradation impacts in companies' ecological balance-sheets. Because of the complexity of products' life cycle and trade flows, ecosystem degradation embodied into enterprises' own products cannot be derived from the spatial information system on the ecosystems or from statistics. The assessment has to be done by the enterprises themselves. This means that ENCA at the level of institutional units (companies) requires their participation and therefore the possibility for them to access the ecological expertise that they need. The challenge is of course important, but prospects are emerging, especially with Big Data¹⁵, which makes it possible to go beyond top-down / bottom-up and think of bottom-up data exchange circuits, including with intermediation platforms, block-chains etc. One can think that many companies might be interested by this proactive approach which would give them more flexibility in the process of internalizing their degradation costs than regulatory or fiscal constraints. Existing initiatives such as the Natural Capital Coalition, The Carbon Disclosure Project or other voluntary schemes, show this interest of self-assessment of their environmental impacts. A standard method and overall assessments allowing them to situate themselves in relation to their competitors might encourage them.

Accounting for the financial risks associated to ecosystem degradation

Important research is being carried out under the aegis of the UNEP Finance Initiative¹⁶. Should be in particular projects like ERISC (Environmental Risk in Sovereign Credit) which methodology aims at the development of metrics and methods for quantifying natural resource and environmental risks so they can be incorporated into country risk assessments used by insurance companies, investors and credit rating agencies. Other projects address various aspects of ecosystem management. One of them focuses on the key role financial institutions play in protecting and building the resilience of the 'blue economy'. *"By considering lending and insurance practices that take into account the health of our oceans they can also preserve the life and economies that depend upon them. Financial institutions can also profit from investing in protecting these precious resources and promoting sustainable marine industries."*¹⁷ It echoes the presentation of the Blue Grants Fund and Blue Investment Fund by the World Bank¹⁸.

Within and outside the UNEP-FI, the finance sector is carrying over important reflections. Thus, the Finance Sector Supplement to the Natural Capital Protocol begins with this very clear quote: *"BNP Paribas Asset Management wants first to map its natural capital impact drivers and/or dependencies to better manage the associated risks and opportunities, with the ultimate goal of limiting its natural capital footprint."*¹⁹ Finance that pushes companies to look for high rates of profit seems to realize today the risks that this implies for them in the long run and therefore for the finance itself.

Similar concerns are expressed in the OECD context through recommendations on the consideration of ESG

¹⁵ Weber, J.-L., 2019, *Towards Ecological Stewardship Based on Spatially Explicit Ecosystem Accounts*, in P. Soille, S. Loekken, and S. Albani (Eds.) Proc. of the 2019 conference on Big Data from Space (BiDS'2019), EUR 29660 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-00034-1, doi:10.2760/848593, 2019

¹⁶ <https://www.unepfi.org/>

¹⁷ <https://www.unepfi.org/ecosystems/sustainable-blue-economy-finance/>

¹⁸ *"Proceeds from the bond will include support for the expansion of marine protected areas, improved governance of priority fisheries and the development of the Seychelles' blue economy. Grants and loans will be provided through the Blue Grants Fund and Blue Investment Fund, managed respectively by the Seychelles' Conservation and Climate Adaptation Trust (SeyCCAT) and the Development Bank of Seychelles (DBS)."*
<https://www.worldbank.org/en/news/press-release/2018/10/29/seychelles-launches-worlds-first-sovereign-blue-bond>

¹⁹ Gaetan Obert, Global Head of Sustainability, BNP Paribas Asset Management.
<https://naturalcapitalcoalition.org/finance-sector-supplement-to-the-natural-capital-protocol-case-study-for-bnp-paribas-asset-management/>

(Environmental, Social and Governance) factors by institutional investors. In its 2017 report on *Investment Governance and the Integration of Environmental, Social and Governance Factors*²⁰, the OCED proposes, following Carney (2015)²¹, to classify climate change risks for financial stability into three categories: *physical risks* (property and trade damage: asset losses and loss of investor confidence, increased cost of credit), *liability risks* (compensation for victims: fines, damages, insurance indemnities and potential risk for the institutions that financed the activities complained of) and *transition risks* (effects of changes in policies, technology and physical risks on asset values: disruption of business models, disordered sector revaluations).

The OECD report insists on two important points of the ESG approach. The first point is that the objective is significantly different from that of ethical investment which aims at objectives outside the interest of the beneficiaries and can therefore in some cases enter into contradiction with it, in particular because of contradictions between (very) short term and long term. For the integration of ESGs, the objective is the protection of the long-term interests of the beneficiaries. The contradictions with the short-term interests remain but must be resolved in this perspective, taking into account the risks for the beneficiaries themselves. The second point is related to various aspects of metrics and models insufficiency, including in the area of climate change integration, which is the focus of the report and the invitation to institutions to invest in this sector. Because ecosystems and biodiversity have no metrics, they are not explicitly covered.

At the European level, the EU Sustainable Finance (or Green Finance) initiative develops on the same line²². Focus is on establishing rules of conditionality of investments, to start with by European banks, to the absence of environmental negative impacts. Pollution and climate change are at the core, ecosystems and biodiversity are not.

Similar remarks can be done with the approach of the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). As of June 11th 2019, the NGFS consists of circa 40 central banks/ control authorities, including European Central Bank, The People's Bank of China, Banque de France, Bank of England, Deutsches Bundesbank, Bank of Japan, Banco de México, South African Reserve Bank, Dubai Financial Services Authority, etc... *"The NGFS aims to contribute to the development of environment and climate-related risk management in the financial sector."* [...] *"Nevertheless, there are compelling reasons why the NGFS should also look at environmental risks relevant to the financial system. For instance, environmental degradation could cascade to risks for financial institutions, as reduced availability of fresh water or a lack of biodiversity could limit the operations of businesses in a specific region. These could turn into drivers of financial risks and affect financial institutions' exposures to those businesses. Also, it is important to be aware of potential greater impacts due to the combined effects of climate and environmental risks. Against this background, the NGFS expects to dedicate more resources to the analysis of environmental risks going forward."*²³

These examples show clearly the importance of the potential role of the finance sector as well as the need of developing the information system and implementing more inclusive approaches to environmental impacts than those focused on climate change alone.

The accumulation of ecosystem degradation recorded as ecological debt in the ENCA balance-sheet and measured in ecological value units (ECU) is a clear indicator of ecological risk. This aggregate can serve as a basis for a rating protocol. It can be implemented at the global, national, sub-national, and local and enterprise levels. The ENCA metric is transparent, reproducible and verifiable. It applies to any type of ecosystem

²⁰ <http://www.oecd.org/finance/Investment-Governance-Integration-ESG-Factors.pdf>

²¹ Mark Carney, Governor of the Bank of England: "Breaking the tragedy of the horizon - climate change and financial stability", 29 September 2015, <https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability> .

²² https://ec.europa.eu/info/business-economy-euro/banking-and-finance/green-finance_en

²³ NGFS, April 2019, *A call for action: Climate change as a source of financial risk* https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf

(including the atmosphere) and allows comparisons in time and space and between economic sectors and agents. It can be implemented globally to initiate a process that will progressively involve all levels of decision making.

The ENCA main features

The Ecosystem Natural Capital Accounts' methodology (ENCA) is the outcome of a process which started in the 1970's with the purpose of incorporating natural values into the national accounts and other assessment and decision making tools. The ENCA-Quick Start Package is a request by the UN Convention on the Biological Diversity of an operational framework to put to work the experimental guidance of the UN System of Environmental-Economic Accounting (SEEA) in order to put ecosystem and biodiversity issues on par with climate change on the international policy agenda. ENCA builds-up on previous experiences, in particular on the land and ecosystem accounting approach initiated at the European Environment Agency.

ENCA: an integrated framework

ENCA is designed as an integrated framework focusing on the measurement of ecosystems' *capability* to reproduce themselves and provide their services continuously, and of ecosystem degradation or enhancement when and where it happens.

All ecosystems are covered by ENCA from the most natural (pristine forests, wetlands...) to the most modified ones (intensive agriculture) and artificial, i.e. the urban systems. Because the ENCA-QSP is a "quick start package", it includes all ecosystems, including the oceans and the atmosphere, but details only land ecosystems. Note that land is in ENCA broader than the usual land cover limited to the coastline. In ENCA, coastal marine systems are included in full. The criterion retained is the possibility to map the sea bottom in a way similar to inland cover. Therefore, coral reefs, lagoons, grass and algae seabed are ecosystem accounting units in their full right on par with transitional waters. In that way, there is a continuum between land and the sea, in particular regarding water issues (sediments flows, telluric pollution) and important biological functions for the sea such as spawning areas, nurseries and more generally habitats for marine life. As long as coastal zones are of the highest importance for both ecological and socio-economic point of view, and under stress from a range of human activities, the ENCA approach provides a realistic basis for accounting for them.

Ecosystem capability is measured for all ecosystems using a unit-equivalent which merges quantitative and qualitative indexes computed in the accounting framework. ENCA's typical aggregated indicator is Total Ecosystem Capability. Measuring ecosystem degradation allows us to assess public and private actors' liability and to propose new policies. It includes the establishment of ecological balance-sheets of countries, sectors and companies to record the accumulation of ecological debts or receivables. In ENCA, monetary valuation comes in a later step for measuring restoration costs in the perspective of reducing ecological debts and ultimately incorporating ecosystem capital depreciation into national and business accounting standards.

ENCA overlaps with other existing frameworks targeting more specific issues such as ecological footprint, water footprint, carbon balances, material flows accounts, human appropriation of primary biomass production, boundary conditions to the use of critical resources, assessment of ecosystem services, and various other indicators sets. While they extend beyond the scope of ENCA, they all have an entry point to ENCA. Mutual benefits of that are possible data sharing and cross-analyses. It is particularly important considering the interpretation of each particular indicator in the light of ecosystem degradation measured by ENCA.

Considering *ecosystem services*, ENCA differs from other approaches such as the present version of the SEEA Experimental Ecosystem Accounting which relates to the standard capital model of the neoclassical economic theory. According to this model, capital is defined as assets which value is equal to the net present value (NPV) of the expected benefits it provides. In the case of the natural capital, these benefits come from the ecosystems services that they provide. The starting point is therefore the assessment of these services. As ecosystem services can be measured in many very different ways, the calculation of an aggregate is done through their valuation in money. Ecosystem accounts established alongside this line tell you what is the capacity of ecosystems to deliver such benefits, the target being their conservation over time. It is a utilitarian approach. As long as ecosystem services are the joint production of nature and the economy, their amount

can be modified by the proportions of the various capitals involved, including by the use of machinery and artificial input, chemicals and others. The information on the resilience of the ecosystem capital itself is unclear.

ENCA addresses the question the other way round. The purpose in ENCA is to measure the resilience of ecosystems over time, whatever services are extracted from them. This potential is called in ENCA their *capability*, which reflects altogether their present capacity and the options kept open for future uses. However, most ecosystem services are recorded in ENCA. They are first of all the provisioning services that include bio-carbon (food, fiber, bio-energy...) and water. These services are recorded in ENCA's accounts of bio-carbon and water, with the same classifications as in economic statistics of commodities in general and in national accounts in particular. The "Use tables" of ENCA corresponds to the supply-and-use tables in physical units (PSUT) of the SEEA Central Framework, which supplement the monetary SUT of the National Accounts. ENCA adds to this description of resources a second dimension in terms of the degradation of the ecosystem by the different economic sectors, which in national accounting terms is not an intermediate or final consumption (as with the SUT) but capital consumption instead. The SNA records Consumption of Fixed Capital, ENCA Consumption of Ecosystem Capital.

Composition of the ecological value index

The measure of ecosystems ecological value proposed by ENCA is conventional for at least two reasons: choice of a goal of good ecological status and composition of the unit value index, which is the currency used to measure ecological value.

Choosing a target of good ecological status

To speak of ecosystems degradation or improvement supposes an agreement on a target, a goal of maintenance and restoration defined with regard to a baseline. Such an approach has been followed in Europe with the Water Framework Directive for which countries had to define a "*good environmental status of watersheds*", and the means to achieve this goal considering the current situation and the cost of restoration measures.

For ENCA, the goal is to maintain ecosystem capability at its current level (and enhance it where and when it is possible); it is a societal goal. This choice is justified by the global signals showing that we have reached the planetary boundaries: acceleration of climate change, acceleration of change in biodiversity, excessive ecological footprint, water use crises ... all traffic lights are red. It is also a choice that is consistent with the principle of accrual accounting for the calculation of income after deduction of capital depreciation. Referring to accrual accounting means that the main focus is on decrease and increase and changes from year to year. There is therefore no need to refer to an ideal situation but to the path of change instead and to the distance to target which can be defined regarding the present situation. We can note that the choice of a recent year was made for climate change, the reference date of which being 1990, and not the pre-industrial era. One could imagine that the same base year is chosen for ENCA.

One may wish to return to a more natural or pristine state, in general or considering the importance of certain ecosystems. From an accounting point of view, there is no difficulty, as long as the objective is defined and validated institutionally by the society, for example as it is done when creating protected areas to restore the ecosystem back to a previous state. This institutional validation is essential given that ecological value accounts being integrated into the management systems of economic actors, they will have practical consequences, and for many of them, costs to remedy the ecosystem degradation.

Some indicators refer to the distance to a goal of a climax natural state, prior to human activity, often called "*potentia*". We can mention the HANPP indicator²⁴ which measures the direct impacts (harvests) and indirect impacts (land use, artificialization of surfaces ...) of human activities on biomass and what remains available for nature or the Second indicator in Australia²⁵, which evaluates the current biodiversity with reference to the

²⁴ **HANPP** : Human Appropriation of Net Primary Productivity. **Econd** : Ecosystem Condition

²⁵ Cosier, P. and Sbrocchi C., 2013, *Accounting for Nature: A Common Currency for Measuring the Condition of Our*

situation prior to European colonization of Australia.

These indicators of distance to potentials are interesting for putting into perspective long trends and the potential for restoration. In the recent period, they can be updated with ENCA which relies on variables similar to those used in both cases. However, the return to biological "*potential*" cannot generally be the objective on which ecosystem accounting should be based.

ENCA refers to the maintenance of systems capability to provide services at a level equivalent to that of a given period. Capability is the potential observed at a given time because of the proper functioning of the ecosystem. Capability differs from the concept of SEEA experimental capacity. The latter defines capacity from the services produced today, assessing their perpetuation over time. The notion of capability of ENCA refers to the good state of ecosystem structures and functions without presuming the future use of these (the future demand of ecosystem services).

Calculation of the ecological value

The formula for calculating the composite ecological value index is itself inevitably conventional because it involves transforming qualities into recordable quantities. Insofar as the formula is transparent and reproducible, this should not pose a question of principle: such composite values are commonly used in university exams, both in terms of the modules justifying the diploma and level equivalence between very distant disciplines; likewise, the rules for calculating the property tax base or the rules for distributing charges between tenants or co-owners, which broadly describe property and refer to a value of that often differs from market values. These valuation rules are subject to a social assessment (and are discussed) which makes them acceptable because of the consensus gained as well as of the transparency of calculation and fairness of application (to all citizens in the same way), and of course possible verification.

The ENCA ecological value unit is called *Ecosystem Capability Unit* (ECU). It is defined by a combination of physical parameters on the intensity of use and health condition of the three components of the accounting model: ecosystem carbon, water, and system integrity and biodiversity. The ECU is used for the synthetic measurement of ecosystems (Total Ecosystem Capability or TEC), their degradation, the amounts to be restored or compensated accordingly and finally the physical assets, receivables and debts of the ecological balance sheet. Ecosystem enhancement is measured in ECU as well.

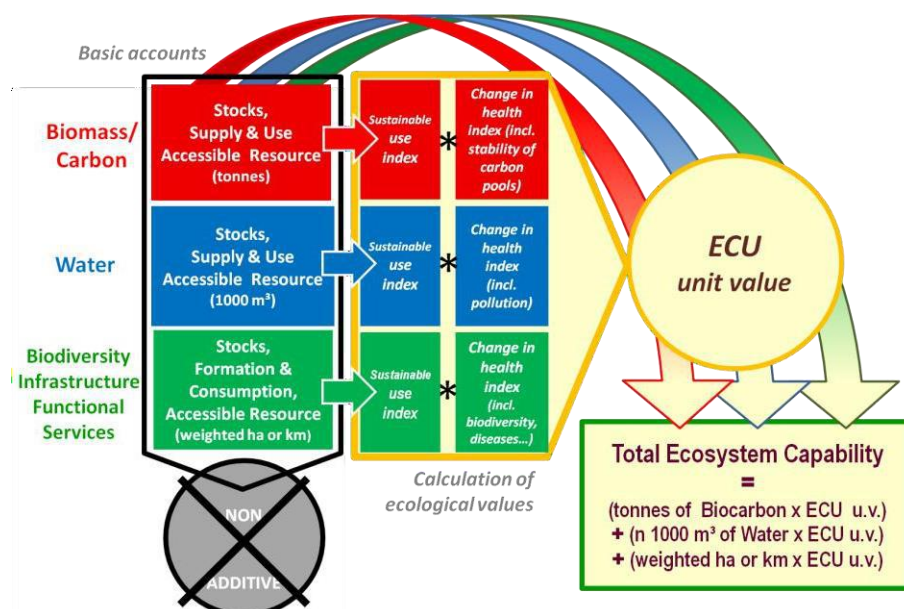


Figure 1: Illustration of the calculation of the Total Ecosystem Capability in ECU

Environment, Wentworth Group of Concerned Scientists, <https://wentworthgroup.org/2013/08/initial-observations-of-regional-environmental-accounts-proof-of-concept-trial/2013/>

Total Ecosystem Capability (TEC) is computed by socio-ecological landscape (or river or marine) units. Basic accounts of Biomass/carbon, Water and Biodiversity infrastructure functional services are established in physical units. They deliver data on stocks, supply and use and the accessible resource. These accounts cannot be added. From the basic accounts are derived indexes of sustainable use reflecting resource depletion. These indexes are supplemented by indexes of health established through diagnosis combining observations and expert judgements. The ecological value is the result of the combination of the three pairs of indexes. It is expressed in a currency called *Ecosystem Capability Unit*. Accessible resources of the three components can be expressed in ECU. The total of the three is the Total Ecosystem Capability (TEC). Decrease in TEC means deterioration, increase enhancement. Deterioration by economic activity is degradation and should be recorded in an ecological balance-sheet in ECU. For a country, change in TEC is an aggregate which can be compared to GDP in order to assess whether or not economic growth is achieved at the expense of the ecosystem's natural capital.

The ENCA data model

ENCA can be implemented at any scale, including in the context of impacts assessment of projects. However, the specificity of ENCA as compared to other ecosystem accounting methodologies is that it ambitions to create a regular information system on ecosystem capital, on par with other accounting systems, private, public and national. Therefore, ENCA proposes a data model that can guide implementations.

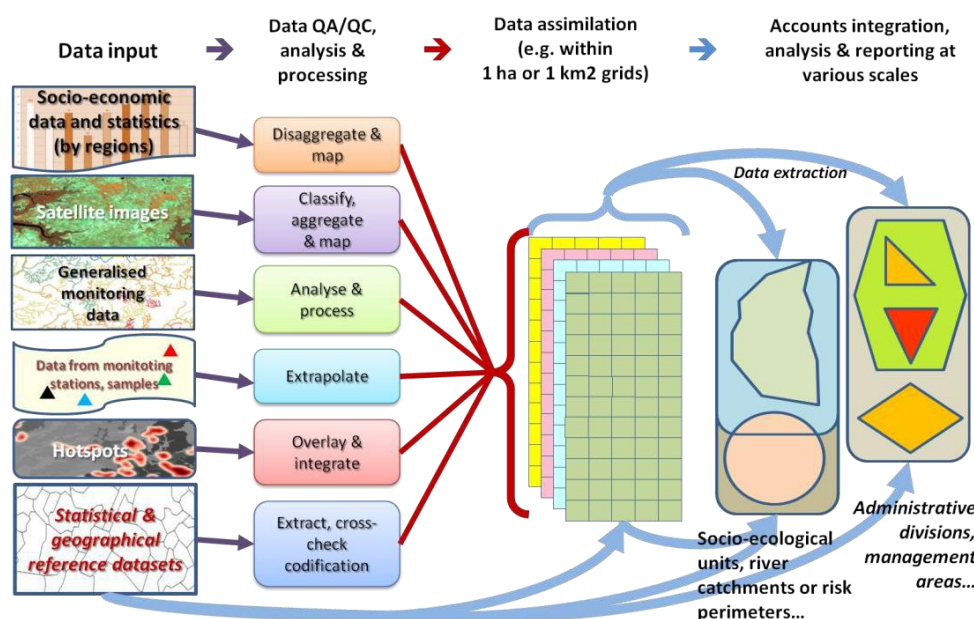


Figure 2: The ENCA-QSP Data Model: Assimilation & Integration of Statistics and Geo-Data

The principle of the data model is to assimilate all datasets into a grid fit for the scale where accounts will be produced. It can be for example a 1 hectare of 1 km² set of grid. Complete accounts cannot be produced in the assimilation grids but for the units for which accounts are produced. Data assimilation to grids allows easy extraction of data. Data sources and formats can be of many types: geographical references, social and economic statistics (possibly by small administrative divisions), satellite images, in situ monitoring data. The data processing depends on the type of data available, but in every case, it starts by a quality assessment. Then, according to data type, processing will consist in classification, resampling, extrapolation, in order to feed the reference grid format. The establishment of time series is an important point of the process as it is a powerful way of controlling the consistency of the available data sources.

First applications of ENCA

ENCA has built upon previous research in environmental accounting, especially at the European Environment Agency (EEA). ENCA has been tested and pilot applications are in progress. At the EEA, land and ecosystem accounts have been published in 2006²⁶ and are updated since then, every 6 years using the CORINE Land Cover inventory's update. Ecosystem accounts at the EEA don't cover the full scope of ENCA but focus on land cover change accounts and derived variables of landscape accounting, in particular the Green Background landscape Index. In 2011, the EEA published, based on its experience, an experimental framework for ecosystem capital accounting²⁷ in Europe, as its contribution to the SEEA-Experimental Ecosystem Accounting process, in the drafting which it was involved in. Several elements were taken in the SEEA-EEA, such as the definition of ecosystems on a geographical basis, but not all. The CBD Technical series 77 of 2014 on ENCA-QSP builds on the EEA report of 2011. In 2012-2013, in parallel to the elaboration of ENCA-QSP, a first experiment was run in Mauritius with the Indian Ocean Commission, the Commission Maurice Ile Durable and Statistics Mauritius²⁸. Although carried out in a limited time, the first experimental ecosystem capital accounts for Mauritius exemplified the interest of the methodology. It was acknowledged by the World Bank, the Global Environment Facility and the UN Environment.

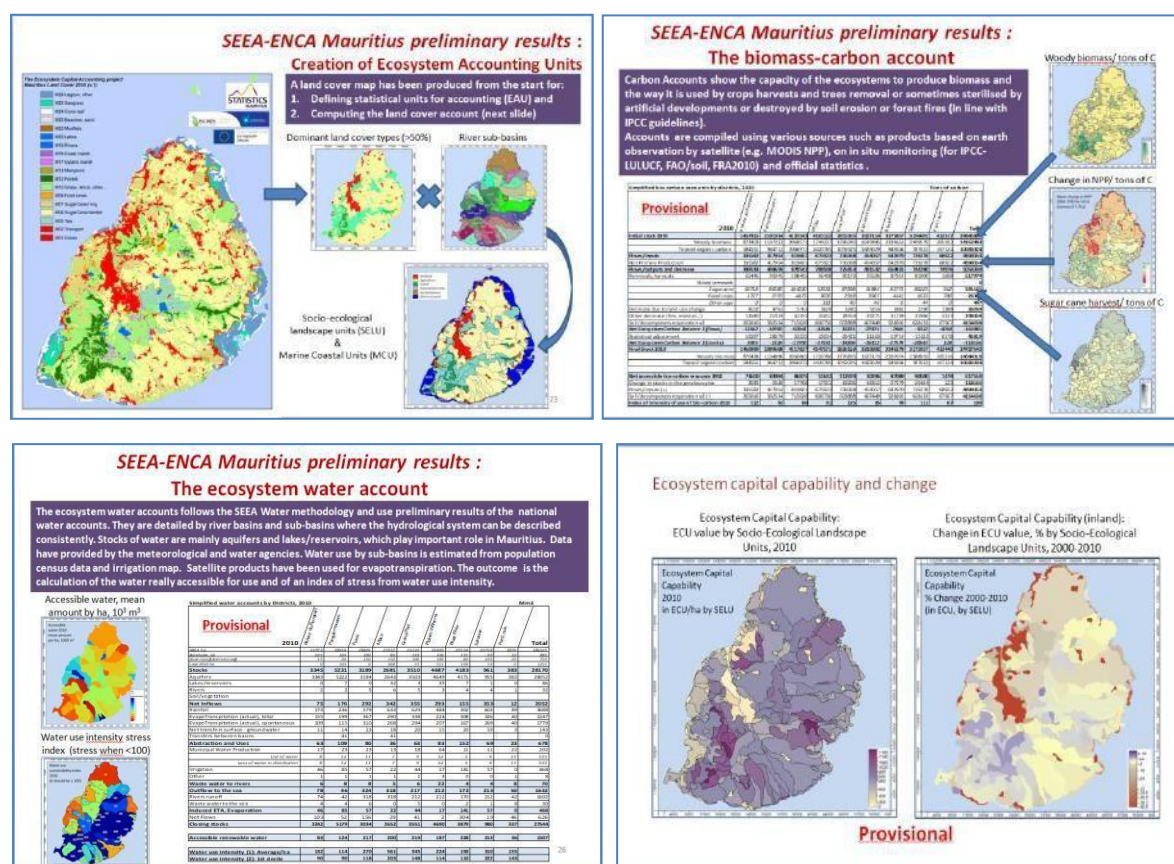


Figure 3: Highlights from the ecosystem capital accounts of Mauritius²⁹

²⁶ Land accounts for Europe 1990–2000, Towards integrated land and ecosystem accounting, EEA Report No 11/2006 (EN) http://www.eea.europa.eu/publications/eea_report_2006_11

²⁷ An experimental framework for ecosystem capital accounting in Europe, J.-L. Weber, EEA Technical report No 13/2011 (EN) <http://www.eea.europa.eu/publications/an-experimental-framework-for-ecosystem>

²⁸ *Experimental Ecosystems Natural Capital Accounts Mauritius Case Study, Methodology and preliminary results 2000 – 2010*, Jean-Louis Weber, Indian Ocean Commission, June 2014. http://commissionoceanindien.org/fileadmin/resources/ISLANDSpdf/Experimental_Ecosystems_Natural_Capital_Accounts_Mauritius.pdf

²⁹ Presentation of Mauritius pilot study 2013 on experimental ecosystem natural capital accounts, Jean-Louis Weber,

In 2016, a two-week French-language summer school was organized in Montreal, Canada, by the CBD Secretariat, the University of Quebec in Montreal and the French CIRAD. It allowed the development of a reflection for a regional cooperation project with the Sahara and Sahel Observatory and 6 countries. This project has got financial support from the French Agency for Development and is starting now. In 2016-2017, an ENCA project in Madagascar was financed by the Global Development Network. The application covered the “New natural protected area” of Antrema and was steered by University of Antananarivo. Since that time, another application has taken place on the island of Nocibé, another natural protected area.

In 2018 a project was launched by the WWF and the French Office National des Forêts – International on the Guyana shield. Are involved the states of Guyana and Suriname, the French overseas region of Guyane and the Brazilian state of Amapá. In 2019, another project is starting, supported by the European Commission and led by IUCN and the Belgian consultancy VITO. The project covers a natural protected area in Western Africa, the Niokollo Park, and its geographical context, i.e. the Fouta Jallon mountains.

Last but not least, in September 2019, a PhD thesis on “*Implementing Ecosystem Natural Capital Accounting Methodology to the Rhone Watershed: the proof-of-concept*” was successfully defended at the National Superior School of Lyon, France, by Jazmín Argüello Velazquez. This is the result of more than 3 years of work and the systematic mining and processing of the best available data in France at the sub-regional to local scales. It proves the relevance and feasibility of ENCA at a sub national scale. It has been carried out by making use of data and statistics presently accessible from public agencies, including data derived from Earth observation by satellite and other maps, meteorological and hydrological data, soil maps, biodiversity monitoring data, agriculture and forestry statistics, population censuses, or administrative registries. ENCA’s data model is guidance for assimilating these very heterogeneous data sources into an interconnected set of grids. However, while accounting techniques based on cross-checking have allowed assessing data consistency and proposing moderate adjustments, they have as well highlighted data gaps which have had to be closed by estimations. Under these conditions, the proof of ENCA feasibility for the 2900 socio-ecological units of the Rhone River catchment is done, including the compilation of their Total Ecosystem Capability aggregate. However, moving from a pilot to an operational information system will require in several cases fixing data gaps with the support and involvement of the various agencies and scientific bodies presently collecting these data.

Indicators, statistics and accounts

Beyond formal approaches to environmental accounting, several methodologies should be considered as accounts considering the exhaustiveness of coverage of their realm, the existence of a common unit of measurement which allows aggregations and of a social or policy target.

The first one is Material Flow Accounts (MFA). According to variants, all material flows can be reported in the framework. The common unit of measurement is the tonne and the policy target is to reduce the ratio Total Material Consumption/GDP. The IPCC reporting framework to UNFCCC is a variant by some aspects of MFA. Better focused than MFA, it defines a common unit of measurement, the CO₂-equivalent which measures the contribution to the state of the atmosphere/climate system, defined in reference to the social target of mitigating warming increase to +1.5° as compared to 1990. HANPP is as well exhaustive and proposes a common unit of measurement (the tonne of biomass) which allows aggregation. The reference to a climatic potential provides useful guidance regarding degradation and possibilities of restoration.

EF, the Ecological Footprint Accounts, are as well formal exhaustive accounts with measurement of biocapacity converted to hectares. They highlight both national or local footprints and footprints embedded into international trade. However, beyond a general idea of reducing our consumption, the relation of the EF metrics to policy or social targets is not clearly defined which makes EF more a communication tool.

The approaches of ecosystem services valuation use broadly the “accounting” term. It relies for part on the fact that they are all variants of costs benefits analysis where the final decision requires valuing all the elements.

Ninth Meeting of the UN Committee of Experts on Environmental-Economic Accounting, 25 – 27 June 2014, New York
http://unstats.un.org/unsd/envaccounting/ceea/meetings/ninth_meeting/UNCCEA-9-8e.pdf

This is called in CBA finding the “accounting price” for those elements which have no clear market price. However, many elements of accounting standards are missing. If a particular CBA is complete in its own case, it is difficult to aggregate the findings of several studies because of their contingency. The same issue exists for ecosystem services assessments which are often difficult to aggregate because of different measurement units. As mentioned previously, the monetary valuation solution is very controversial as it implies a utilitarian approach of the natural capital and the acceptance of the low sustainability paradigm.

The use of the accounting terminology regarding the Planetary Boundaries set of indicators is as well misleading. These indicators are not formally connected and their transcription in DPSIR is certainly helpful but does not make the framework an account. It would be better to speak of “counts” here that of accounts, which would help define more clearly their status within the various approaches listed above.

Finally, a link should be made between integrated environment accounting and the SDG indicators. Their low integration makes them the expression of a collection of targets more than a structured programme. Ecosystem natural capital accounting could help the implementation of indicators relevant to the subject in two ways. Firstly, accounts could help in introducing more consistency. Secondly, in several cases, the ENCA database could be used for providing the needed SDG indicators related to ecosystem issues. Figure 4 is an illustration of the way ENCA could interact with other frameworks, either to support their reporting or, in other cases, to use the data which have been collected for their particular purpose.

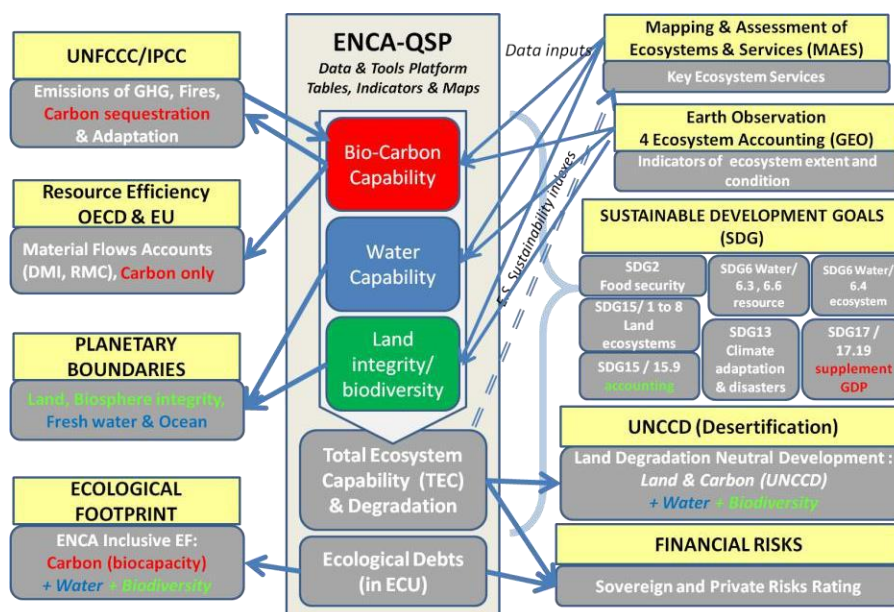


Figure 4: ENCA and main indicators frameworks

ENCA, the ECU Metrics and Novel Policy Measures

The implementation of the ENCA could be done right now. The first step should be the implementation of spatially based and annually updated global accounts, which would change the terms of the debate on biodiversity. This discussion needs to be addressed globally, as was done in Kyoto for the climate. Computer technology and the main databases required today exist to produce the first simplified but complete and verifiable ENCA in one year. It will then be progressively enriched and improved by national, regional and specific programs, for example for sensitive areas such as protected natural areas or coastal zones, and by the economic agents themselves for their own purpose.

The existence of global simplified ecosystem accounts would make it possible to start discussing the implementation of new measures without delay, with no need to wait that all countries have produced their own accounts. Global accounts can be produced centrally and implemented on IT platforms and verified with satellite imagery. They would trigger the implementation of more detailed accounts at regional, national and sub national levels. Full implementation of detailed ENCA would result in national decisions and of

encouragement to economic actors to develop their own ecosystem accounts (beyond their carbon balances).

In the EU for example, the EMAS regulation includes a conditionality clause which already requires the disclosure of an environment management plan³⁰ to be eligible for public procurements. It could be expanded to ecosystem capital accounts reporting and disclosure. In the first period, holding and disclosure of an ecological balance sheet in the ENCA format could be included in EMAS, without any obligation in terms of accounting result. After a trial period, the requirement could be more demanding, for example in terms of net ratio of ecological debts to ecological capital. To meet such a ratio, companies would have to restore the ecosystems that they have degraded or obtain ecosystem credits in ECU from entities holding ecological receivables due to their (certified) contribution to ecosystems enhancement or to conservation of high natural value areas. These data being available to auditors, rating agencies, insurance companies and banks, this would create a leverage effect and supplement the governmental pressure (taxes and regulation). In the obligation to internalize their degradation costs, the companies themselves would then request the inclusion of ecosystem natural capital depreciation in the financial accounting standards. Symmetrically, the opportunity to access compensation funds, for example by leasing their ecological receivables, would provide a resource for the stewardship of protected natural areas (compensation of degradation avoidance costs borne by population) and an incentive for ecosystem restoration programmes, particularly in countries which have a comparative advantage because space is abundant and labor costs low.

Ecosystem governance would require rules and mechanisms. They should include verification schemes to certify ecological receivables related either to the creation of new ecological credits by ecosystem enhancement (which should not be confused with restoration from ecosystem degradation and debt reduction) or related to allocations for conservation of high nature value ecosystems. It should include mechanisms to certify the extinction or compensation of ecological debts, which must be measured in ECU and not in money. Settlements in ECU should be regulated by institutions to allow market fair and transparent functioning and the use of modern technologies such as, for example block-chains and intermediation platforms. Accounting for ecosystem capital degradation in the systemic way proposed by ENCA would broaden the scope of actions that have started under the generic name of “*green finance*”, which are today too segmented because too narrowly focused on emissions of CO₂ and on pollution. A more holistic approach to biosphere degradation based on sovereign and corporate ecological debts indicators measured in ECU would broaden the scope of the environmental risk factor taken in investments financial risks assessments.

More broadly, assessment of individual liabilities to ecosystem degradation will require particular attention. Indeed, ecosystem overall deterioration and the share of it which can be considered as degradation by human activities can be observed by monitoring systems and reported following the guidelines of ENCA-QSP. From an individual actors’ point of view (producers, consumers, planners...), it is more complicated as responsibility can be direct through their own decisions or indirect through their purchases of commodities. Considering direct responsibility, distinction has to be done between individual impacts and collective impacts. Individual impacts appear e.g. by clear felling a forest plot, by soil sealing with infrastructures or by degrading soil by intensive agriculture. They can be directly assigned to the responsible unit. Collective impacts reveal at a higher scale. It can be firstly the impact of a given actor’s action on the entire ecosystem where it is acting degradation of the whole socio-ecological unit, of the river catchment... It can be as well an action (excessive abstraction, emission of pollutant) which is not individually significant, but which generates degradation being agglomerated with others. Well known cases are depletion of aquifers which is assessed at the scale of the aquifer itself, or urban air pollution by traffic and of course of GHGs contribution to global warming. Indirect liabilities are those of intermediate and final consumers. The issue is addressed at the global scale in accounting frameworks of the “ecological footprint”, “embedded carbon”, “water footprint”. Presently, such accounts only consider flows in quantities, not the environmental impacts on the ecosystems from which they originate. ENCA-QSP suggests that such footprints could be incorporated in the broader ecosystem capital accounting framework in a more inclusive way reflecting degradation. The challenge here relates to the

³⁰ EMAS : Eco-Management and Audit Scheme of the European Union.

traceability of individual flows through the development of products life-cycle analysis involving the companies participating in the international trade.

The case of degradation induced by causes which are external to local or individual liability such as natural disasters and climate warming will also have to be addressed. ENCA makes a clear distinction between observable ecosystem deterioration and the degradation which results from our behaviors. Only liability to degradation should be taken into account in settlements mechanisms. It poses the problem of induced ecosystem degradation caused by populations under stress because of disasters, in particular slow developing disasters such as droughts. Similar issue appears with coastal populations deprived from their traditional fish resource by intensive fisheries. It suggests that ENCA should not be only connected to economic accounts but as well to social accounts, which don't exist yet.

Conclusion

The concern about climate change is very high. So is the concern of biodiversity collapse. If the discourses overlap to some extent, the approaches are still different. One reason is that climate policies relate on a model supported by a reporting system which is familiar to decision makers. The model is the relation between GHGs concentration and the temperature of the atmosphere. The reporting system is that of the IPCC guidelines, the so-called "carbon" budget and accounts. On that basis, targets can be quantified (no more than +1.5 or 2°C as compared to 1990), commitments (pledges) taken, verification mechanisms implemented and even "carbon" trading attempted. More and more frequently, complaints from policy makers are that we don't know how to measure what could be "+1.5° biodiversity" or the biodiversity equivalent of "1 tonne of CO₂". This is the more worrying as researches suggest the fast degradation of the biosphere, on land and in the sea, resulting from overexploitation is an important contributor to global warming. ENCA is certainly far from being perfect but it proposes a solution to the recurrent policy demand for a metric for biodiversity, the measurement in ECU. As long as the ECU format for measuring ecological value encompasses altogether biodiversity, water and bio-carbon, ENCA may provide useful warning to policies at risk of being unilateral because guided by one single indicator. There is room for progress, either regarding some ecosystems – namely the ocean – which are insufficiently described and monitored or the ways to translate the on-data ecosystems into information and knowledge that everybody can use on a routine basis. First experiments show that EN is feasible. More, the swift progress of information technology regarding satellite and in situ monitoring (where high space and time resolution are the state of the art) as well as computing platforms with huge capacities, and the Big Data, make the project affordable now.

MARINE ORGANISMS RESPONSE TO CLIMATE CHANGE EFFECTS IN THE WESTERN INDIAN OCEAN

Hollander J.¹, Linden O.¹, Gudka M.², Duncan M I.^{3,19}, Obura D.², James N.^{3,4}, Bhagooli R.^{5,11,22}, Nyanapah J.⁶, Onyango C.⁷, Duvane J.⁸, Louis Y.⁵, Ngotho D., Mvungi E.¹⁰, Mamboya F.¹¹, George R.¹², Hamad H.¹³, Issa Hamisi M.¹⁴, Adeleke B.⁷, Ngoa E.¹⁵, Harlay J.²³, Oduor, N.¹⁷, Fondo E.¹⁷, Wambiji N.¹⁷, Raharinaivo L.¹⁸, Winkler A.¹⁹, Okemwa G.¹⁷, Karisa J.¹⁷, Madi Bamdou M.²¹, Mtaki K.²⁰, Randrianandrasana J.¹⁸

*Corresponding author: World Maritime University | Global Ocean Institute, 211 18 Malmö, Sweden. E-mail address: johan.hollander@wmu.se (J. Hollander).³²

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Abstract

There is widespread consensus among climate scientists today that global climate change is real and has anthropogenic roots. Marine species, for example, are exposed to a large array of abiotic stressors, such as warming and ocean acidification, that are linked directly to anthropogenic climate change. The general view on whether natural populations can adapt to anthropogenic change is that many species will fail to adapt to rapid climate change effects. This accelerating trend has profound effects on marine species and ecosystems, globally and the Eastern African region is no exception. Here, we provide a review that is the result of the workshop “Marine Organisms Response to Climate Change Effects – Adaptation or Extinction?” among ocean scientists actively studying the impact of climate change in the Western Indian Ocean. The review examines several key marine organisms and ecosystems in the region of the Western Indian Ocean, how these may be impacted by climate change, and the way forward for successful conservation and management.

³¹ The Biodiversity and Environment Institute, Reduit, Republic of Mauritius

³² Facts and opinions published in the Journal of Indian Ocean Rim Studies (JIORS) express solely the opinions of the respective authors. This in no way represents the views of IORA. The Authors are responsible for their citing of sources and the accuracy of their references and bibliographies. The editors cannot be held responsible for any lacks or possible violations of third parties' right.

Introduction

Global climate change has emerged as a major problem for humanity, challenging many aspects of human life today and compromising the life of future generations. The repercussions expand beyond human welfare, with most ecological communities on land and in the oceans, in polar, temperate and tropical areas affected. In the marine environment, climate change alters the physio-chemical properties of the ocean, with changes in temperature, oxygen concentrations and pH having impacts on all marine organisms (Somero 2010). The Intergovernmental Panel on Climate Change (IPCC) predicts an increase of temperature of between 3–5 degrees by the end of the century. Such extreme change will unquestionably expose coastal and marine ecosystems to environmental stress at dangerously high rates. The question is to what extent natural populations can adapt to anthropogenic changes. Unfortunately, many scientists today predict that key species will fail to adapt to such rapid climate change, and that many ecosystems will change fundamentally resulting into significant loss of biodiversity (IPCC 2018).

In the Western Indian Ocean (hereafter, WIO), these problems are real and very often acute (Wilkinson et al., 2000; Obura et al., 2002; Mahongo 2009; Ateweberhan & McClanahan 2010; Watkiss et al., 2012; George et al. 2018). Increasing human populations have also changed historical land use patterns, in the form of urbanization of rural areas and increasing the area of cultivated land. These changes will continue to reduce the quality and quantity of drainage water with impacts on coastal ecosystems of the WIO (e.g. IOC-UNESCO, 2016; Okuku 2007; Mvungi & Pillay 2019). Additionally, cyclone strength and frequency are increasing, influenced by increasing Sea Surface Temperatures (SST) that add energy to the atmosphere (Mahongo et al. 2014).

Ramirez et al. (2017) identified the WIO as one of six hotspots of marine biodiversity globally that are particularly affected by global warming, with the list of consequences growing longer each year (George et al. 2018; Mahongo; 2011; Mahongo et al., 2014; Mvungi & Pillay, 2019). This text will focus on a few of the most important coastal ecosystems and organism groups in the WIO which provide essential ecosystem services in the region, and which are now facing serious stress from climate change; fish, coral reefs, seagrasses, and mangroves. The article will describe and discuss the results of past and ongoing climate change related research. Finally, the article will try to widen the scope and discuss climate change effects on the whole in the WIO region, conceptual and/or infrastructural improvements, and research avenues that have been overlooked or need further exploration. However, providing a complete review of climate change impacts is beyond the scope of this article.

The ideas and concepts presented below are the result of discussions at the workshop “Marine Organisms Response to Climate Change Effects – Adaptation or Extinction?” among experts, scientists and researchers actively studying the impact of climate change in the WIO. The workshop was funded by WIOMSA and organised in collaboration with Lund University and the World Maritime University, in Mombasa, October 2018. In relation to this special issue on Blue Economy in the Indian Ocean, this article focuses on how the responses of marine organisms and ecosystems to climate change may affect their ability to provide and sustain ecosystem services that are the foundation of the blue economy. Biodiversity and ecosystem functions generate the products and services used by people (UNECA 2016, Attri 2016, Obura 2018), so the ability of organisms and ecosystems to adapt to or withstand climate change will fundamentally affect the level and stability of service provision into the future.

Corals

Key ecosystem characteristics, features and distribution

Coral reefs are perhaps the most biodiverse of ecosystems globally and among the most productive, hosting up to one quarter of marine species at some point in their life cycle (ref). In the WIO, they are one of the dominant shallow marine ecosystems, fringing the coasts of mainland East Africa and the islands of the region (Obura 2015). Their high productivity provides fish and other food, protects the coastlines from storms and generates a

range of additional ecosystem services that support rural and urban population, tourism and recreation sectors and biomedical sciences (Eliff & Silva 2017).

There are some 400 species of reef-building coral in the WIO (Obura 2012, Veron et al. 2015), and their symbiosis with intracellular dinoflagellates, zooxanthellae, drives the coral reef ecosystem. Photosynthesis by the zooxanthellae generates excess energy used by the coral to grow and rapidly secrete their calcium carbonate skeleton, which over multiple generations of corals growing on the skeletons of their ancestors builds the reef system. Corals and their symbiotic algae need clear warm tropical waters and are restricted to shallow (< 30 m) rocky bottoms not too close to rivers that discharge turbid water and silt into the sea. The symbiosis is, however, vulnerable to high temperatures. Whitening, or bleaching, of the coral occurs in response to exposure to excessively high temperatures (as well as other stress factors) (Obura 2009). If the stress is not excessive the bleached coral may recover, but if excessive, mortality occurs. Thus, corals are highly vulnerable to climatic warming of the last decades (Hughes et al. 2018.), and WIO coral reefs have gone through two major bleaching events in 1998 and 2016, as well as smaller events in between (Obura et al. 2017, Gudka et al. 2019, McClanahan et al. 2014).

All countries in the WIO, both mainland and island, contain coral reefs within their territorial waters. The most common type of coral reefs are fringing reefs which generally contain patch reefs in adjacent shallow lagoons. There are also isolated atoll reefs around some small islands as well as barrier reefs notably in Toliara, Madagascar and the region also has large submerged reef banks in the Mascarene Plateau (Ahamada et al. 2002). Discharge of freshwater and sediments from major rivers into shallow waters generally creates conditions unsuitable for corals to live, leading to natural breaks in extensive coral reef formations in several countries.

Comoros Islands have a total of 430 km² of coral reefs with at least 195 reef-building coral species (Ahamada et al. 2008; Obura 2012). Mayotte's lagoon covers 1500 km² and harbours at least 249 reef-building coral species. Kenya's coral reefs cover an area of approximately 639 km², and are differentiated into two regions: the more-diverse (239 species) southern reef is an almost continuous fringing reef system from Malindi to Tanzania and the northern lower diversity discontinuous patchy and fore reef slopes from Lamu to the border with Somalia. Madagascar has 3450 km of coral reefs, comprising 1130 km of fringing reef, 502 km of barrier reef, 557 km of coral banks and 1711 km of submerged reef (Cooke 2012). The northern part of Mozambique is characterised by extensive, highly-biodiverse coral formations fringing the coastline and the surrounding island groups. The southern half of Mozambique and the extreme north-eastern part of South Africa (approximately 40 km² reef area) consist of marginal, non-accreting coral reefs generally dominated by soft corals. Réunion, the youngest island, has short stretches of narrow fringing reefs along southwestern coasts (Turner & Klaus, 2005) with a total length of 25 km and an area of 12 km². Coral reefs cover an area of approximately 1,690 km² in the Seychelles, with most reef areas located in the outer islands. Tanzania's fringing coral reefs consist of at least 273 species are located along about two thirds of Tanzania's continental shelf and surround most of the islands (Obura 2017). Mauritius Island consists of a discontinuous fringing reef, small barrier reef and large lagoon patch reefs and Rodrigues Island has nearly continuous fringing reefs with both islands having approximately 240 km² of shallow reef habitats (Turner & Klaus, 2005).

Description of benefits

Coral reefs are home to and support close to a quarter of the ocean biodiversity including fish. In this way, they support small-scale artisanal fisheries essential for the supply of protein for numerous people in the WIO. Reefs also generate income from tourism, and they protect the coastline by reducing wave energy and wave height, hence protecting coasts from erosion. Unfortunately, corals are sensitive to elevated temperatures and many experts including the IPCC predict that they will be the first ecosystem to effectively become extinct as a result of ocean warming (1.5 C IPCC report).

The impacts on coral reefs as a result of ocean warming have been studied extensively in the WIO region (Obura 2005; Gudka et al., 2019; McClanahan et al., 2007; Obura et al. 2018). Although ocean temperature increases occur globally, in the tropics and subtropics, the rate of rising temperature can vary across regions and at local scales (Hoegh-Guldberg et al. 2007; Hughes et al. 2017), contributing to variation in the resilience of coral reefs

to cope with temperatures and temperature spikes (McClanahan et al. 2007). Many factors affect local variation in temperatures and the responses of corals and their symbiotic algae, potentially imposing directional selection and local adaptation or phenotypic plasticity (West & Salm 2003, Obura 2005, Obura 2009, McClanahan et al, 2014; Pratchett et al, 2013).

Ocean acidification causes negative impacts on calcifying species like phytoplankton, molluscs, corals and coralline algae (Harvey et al. 2013). For species with a calcified skeleton, the lower pH will impede building a calcium carbonate (CaCO_3) structure (Doney et al. 2009). Still, these effects will be most pronounced in colder regions than in the tropics, since warmer temperatures stimulate faster growth and development by a higher metabolism (Byrne 2011) which may counteract the negative effects of acidification (McNeil et al. 2004; Kleypas and Yates 2009). At the moment, the impact of sea level rise is not considered a major threat to coral reefs in the region, as the progression of sea level rise may be within the growth rate of most corals (Anthony & Marshall 2009).

Other than direct stressors, there are several synergistic indirect stressors that are influencing corals negatively. For example, a stressed coral reef will be more susceptible to coral diseases, which encompasses pathogenic fungi, bacteria or viruses that may reduce growth rate, impair reproduction and cause direct mortality (Harvell 2007). Many of these diseases are still relatively unknown, but today we see strong correlations between the appearance of such pathogens after acute stress events such as coral bleaching and tropical cyclone damages (van Hooidonk & Huber, 2006; Randall & van Woesik, 2015; 2017). There are also processes that are often not immediately associated with global climate change effects such as eutrophication and pollution from various sources, that accentuate the pressure on corals and associated species. Currently in the WIO, warmer sea surface temperatures and El Niño-Southern Oscillation effects are generating stronger and more frequent cyclones and heavier storms, which also affect new geographical areas that previously have been spared from such events (Fitchett & Grab 2014). The region also experiences greater variation in precipitation, with the resulting run-off from land carrying solid waste such as plastics, nutrient pollution (mostly nitrogen and phosphorus), suspended sediment and chemicals as well as metals from industry and agriculture. Finally, increased temperatures and alterations in ocean circulation and currents cause changes in cold and warm water areas and allow new and sometimes deleterious species to migrate and invade new areas.

Future Research Areas

Previous research in the region has largely focused on the genus *Acropora* (Baird et al. 2009; Meyer et al. 2011; Mattan-Moorgawa et al. 2012; Louis et al. 2017). Certainly, more studies on additional species are required, in particular comparative studies on temperature response, both in the laboratory and in the field. A few key genera that have been suggested for such studies are *Porites* and *Favia*. Nevertheless, for better management of coastal ecosystems including coral reefs, research must also focus on rare and endemic species in the region (e.g. *Anomastrea* sp.) that possess a high conservation value, and need protection of their habitats, particularly species that live in critical habitats. Better knowledge about the sensitivity and robustness of different taxa and populations to climate warming, possible acclimatization to changing conditions and the possible existence of unique genetic makeups with a stronger resilience towards warming are essential aspects to be considered. A relevant question is if priority should be placed on species that are ecosystem engineers, those with higher resistance to extreme conditions, or rare or endemic species.

Moreover, adaptations in corals to climate change is a complex process, but we know variations exist in traits and that selection occurs. In order to understand local morphological adaptations, behavioural changes and variation in gene expressions, long-term monitoring programs are required because adaptations can vary among species and across populations. This research should include a focus on the symbiotic dinoflagellates, now known to be highly variable at high levels of classification (LaJeunesse et al. 2018). This particular field provides several new and important research directions in terms of understanding coral resilience. For example, there may be specific micro-organisms or certain microbe communities that facilitate corals resistance against bleaching or invasive microorganisms which can drive shifts in these unique symbiotic microbial communities, obstructing selection towards adaptations or even make corals more vulnerable to bleaching.

Opportunities for future work

In the WIO, there are several research groups focusing on coral research. These research groups are either affiliated with universities, governments or various NGOs. Most of the research commenced after the serious bleaching event that hit the region in connection with the 1997/98 El Nino event when sea surface temperatures increased by several degrees killing up to 90% of corals on many reefs of the region (Obura, 1999; Wilkinson et al., 1999; Goreau et al., 2000; but also CORDIO Reports 1999, 2000, 2002, 2005 and 2008). However, research in the WIO region is challenging since there is very little local funding available. In addition, the region is large and comprises both mainland countries and island nations, which make logistics and management demanding. Even if it is today possible to forecast bleaching events (Donner et al. 2017), as they until now has been associated with El-Nino-events, and substantial research has been accomplished to understand coral responses to elevated temperatures (Hoegh-Guldberg et al. 2007; Hughes et al. 2017), there is a lack of contingency funding which can be mobilized in the event of a new mass bleaching event. In addition, there is little knowledge of species-specific responses to rising temperatures.

To achieve such essential knowledge, new research is required in several fields. Taxonomic research, for example, has unfortunately been underfinanced for many years in all areas, not only in the marine realm. Still, museums around the world provide funding for larger sampling campaigns required to identify and classify new species. Such research is of key importance also when it comes to forecasting the ability of different species to survive the various impacts of climate change. Without correctly identifying which organisms comprise an existing healthy coral microbial community, the understanding of invasive/introduced species dynamics, or even the identification of unique genetic constitutions of certain coral populations will be impossible. This would obviously entail substantially more man hours of field research to map coral reefs around the WIO region in detail, but also to conduct laboratory and mesocosm experiments, as well as to conduct targeted meta-population molecular studies.

Coral reefs are complex habitats, and a change in one end of the system will cascade and produce a multitude of consequences elsewhere. To try and understand the various changes occurring to coral reefs, the WIO needs formal, coordinated research groups and consortiums of laboratories, which can combine and expand efforts. One important focus of such research groups would be to prepare a strategic monitoring plan for any impending major bleaching events in the region, as these are likely to become more common in the next few years. This would require a funded regional contingency plan, core-funding secured for long-term monitoring, and a plan to study pre-determined measurement indicators at sentinel sites; during pre-, peak- and post-mass bleaching events.

Similarly, there is a need to develop research and monitoring related to ocean acidification. The Global Observation Ocean Acidification Network (GOA-ON) and OceAn pH Research Integration and Collaboration in Africa (ApHRICA) are pilot projects to deploy ocean pH sensors in the WIO for the first time. The initiative aims to improve knowledge and to provide selected teams with training and basic observation equipment, the "OA" toolkit. However, only a few research teams up to now have received these toolkits and initiated the first observations. Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean (SOLSTICE-WIO) is a project funded by the UK Global Challenges Research Fund (GCRF) that raises awareness and transfers knowledge on climate change issues to local researchers and students. The long-term objective of all this work is to create a local research community of practise for ocean acidification and other stressors on the marine environment and relate the ocean acidification observation to species and ecosystems of socioeconomic importance to make the science relevant for society.

Table 1. Description of marine conservation biology actions and their putative impacts on key organisms in the WIO region.

Actions	Taxa	Impacts
Assess local adaptations and resilience	Fish, corals	Predictive accuracy of species responses to climate change
Contingency funding	Corals	forecast bleaching events
Species-specific responses	Corals, seagrasses, mangroves, fish	Identify vulnerable or robust taxa
MPAs	Corals, seagrasses, mangroves, fish	Protection of species that withstand extreme conditions, and rare endemic species
Improved molecular labs	Corals, seagrasses, mangroves, fish	To identify population structures, species and rare allele combination, gene expressions, and traits
Focus on symbiodinium dinoflagellates and associated microbes	Corals	Symbiotic microbial communities can drive coral adaptations and resilience
Taxonomic research	Corals	Invasive species can obstruct selection
Establish baseline information	Corals, seagrasses, mangroves, fish	Improve comparative studies before and after extraordinary events
Improve ecosystem-based services	Corals, seagrasses, mangroves, fish	Mitigates global climate change. Simultaneously highlights and protect key species or ecosystems, and improve ocean conservation biology and biodiversity
Standardize research and sampling methods	Corals, seagrasses, mangroves, fish	Improve validation and statistical power across the region
Support for long term monitoring studies	Corals, HABs, pH	To enable forecasting future extreme events
Develop core lab facilities for molecular techniques	Corals, seagrasses, mangroves, fish	Assure the availability of expensive molecular equipment, and support specialist training in the region

Seagrass and mangroves

Key ecosystem characteristics and features

Seagrasses in the WIO are intimately associated with coral reef habitats, growing on sandy as well as hard-substrate bottoms, and dominating the shallow lagoons and some shallow reef slopes throughout the region. They may also grow sub-tidally in protected bays, estuaries and semi-enclosed sites, closely associated with mangroves that dominate the intertidal zone along these coasts. Mangroves and seagrasses are the only two groups of vascular plants that have adapted to life in saline water. The general ecology of seagrass ecosystems and mangroves has been well covered elsewhere (see for example: Linneweber and Drude de Lacerda 2002; Green et al. 2003; Hemminga and Duarte 2008; Hogarth 2015). For that reason, we will mainly focus our efforts to discuss conditions specific to the WIO.

Distribution

Seagrass beds and mangrove forests are found throughout the WIO region. Of the estimated 1 million hectares of mangroves in the WIO region, about 90% is found in Kenya, Tanzania, Mozambique and Madagascar (UNEP/Nairobi Convention 2009). Thirteen seagrass species are reported along 12 000 km of the region's coastline (Gullström et al. 2013).

Description of benefits

Historically, less research has focused on the ecology and physiology of seagrasses compared to coral reefs and mangroves. However, today the situation is changing, and research related to the ecology of seagrasses and their role in the lifecycle of other marine organisms has increased dramatically (e.g. George et al. 2018; Lyimo et al. 2018; Bouma & Infantes 2019; Meysick et al. 2019). Important research has also focussed on the ability of seagrasses to adapt to climate change and the role of seagrasses in the carbon cycle e.g. the long-term uptake of atmospheric carbon, referred to as blue carbon (Duarte et al. 2005, 2010; Kennedy et al. 2010; Mcleod et al. 2011; Fourqurean et al. 2012; Alongi et al. 2016; Lyimo et al. 2018; Gullström et al. 2018).

Mangrove forests and seagrass meadows constitute multifunctional, high-productivity ecosystems that serve as spawning and/or nursery habitats for a wide variety of fish and invertebrates (de la Torre-Castro & Rönnbäck 2004; Hughes et al. 2009; de la Torre-Castro et al. 2014; Nordlund et al. 2018), thus are key fishing grounds (de la Torre-Castro & Rönnbäck 2004; Unsworth & Cullen 2010; Nordlund & Gullstro 2013). In addition, some birds, reptiles and even mammals depend on both habitats for their survival. For example, researchers have identified 40 different fish species, 125 sessile species and 72 species of attached microalgae associated with seagrass meadows (Moksnes et al. 2008). Mangroves and seagrasses are accordingly keystone habitats providing ecosystems with high biodiversity (Duffy 2006; Blaustein 2008). Furthermore, these types of vegetation along the coast can reduce wave height and energy (Lacy & Wyllie-Echeverria 2011; Manca et al. 2012) and enhance the accumulation of sediment (Potouroglou et al. 2017). Sediment accumulation in seagrass meadows is highly beneficial as it keeps sediment from leaving the shore (Lacy & Wyllie-Echeverria, 2011; Manca et al., 2012; Duarte et al. 2013; Spalding et al. 2014), hence counteracting coastal erosion. The root systems of mangroves and seagrasses bind the sediment and the shoots, while stems and leaves slow down water movement (Ginsberg & Lowenstam 1958; Fonseca et al 1983; Saenger 2002), and protect shores from erosion.

Mangroves and seagrass meadows also have the ability to reduce turbidity, making the water clearer by lowering the horizontal transport of suspended sediments and thus moderating sedimentation impacts on adjacent coral reefs (Duke & Wolanski 2000; Schaffelke et al. 2005; De Boer 2007). However, human activities have increased run-off from land and elevated water turbidity including the levels of nutrients, with negative impacts on the plants and associated organisms (Mohammed 2002 Hamisi et al. 2004; Uku & Björk 2005; Hamisi et al. 2009; Huxham et al. 2010). Elevated water temperatures caused by global warming have been reported to negatively influence productivity of tropical seagrasses in the WIO region (George et al. 2018) and these negative effects are exacerbated by local stressors e.g. eutrophication (Mvungi & Pillay, 2019). Such disturbances have also been

shown to increase methane emission together with sulphide concentrations in the sediments (Lyimo et al., 2018), where high levels of sulphide could enhance seagrass mortality due to sulphide toxicity.

Seagrass meadows have also been proposed as ocean acidification refugia because of their ability to respond positively to changes in carbonate chemistry by storing more CO₂ as Blue Carbon (Cyronak et al. 2018). This, in turn, has the potential to locally reduce ocean acidification by increasing pH and aragonite saturation (e.g. Yates et al. (2016). Such biogeochemical services provided to the coral reef system by not only seagrass meadows but also mangrove, are highlighted particularly in Seychelles for the Indian Ocean (Camp et al. (2016) and provide a strong conceptual framework for conservation efforts.

The protection and management of mangrove forests together with seagrass beds are categorised as one of the most important elements of blue carbon strategies to mitigate climate change (Laffoley & Grimsditch 2009; Nellemann et al. 2009; Duarte et al. 2013). Peat formation in mangroves comprises a substantial carbon sink (Ong 1993), and in Kenya, seagrass beds are 4-6 times higher in sediment carbon compared with un-vegetated controls (Githaiga et al. 2017).

Unfortunately, these habitats are today threatened (Waycott et al. 2009). The main reason for the loss of mangrove vegetation and seagrass meadows along the coasts of the oceans is overharvesting, reclamation, eutrophication and the use of destructive fishing techniques (Larkum et al. 1989; Stapel et al. 1996; FAO 2007; Hamad et al. 2014). Not only does seagrass function as nurseries for a large diversity of marine species, seagrass act as essential fish habitats contributing towards key fishing grounds (de la Torre-Castro & Rönnbäck 2004; Unsworth & Cullen 2010; Nordlund & Gullstro 2013). Seagrass-based fisheries are extremely important for coastal livelihoods as traditional small-scale fishing activities support millions of people (Barnes-Mauthe et al. 2013; de la Torre-Castro et al. 2014). However, fishing methods such as bottom trawls, beach seines, explosives, poisons and rakes are destructive to seagrass habitats (Nordlund et al. 2018).

With elevated sea levels, mangroves and seagrass meadows may, in suitable areas, be instrumental to mitigate the effects of strong winds, tidal waves, sea surges, tsunamis, and shoreline erosion (Mazda et al., 2007; Godoy & Lacerda, 2015). However, with sea-level rise, mangrove forests may be flooded and seagrass beds silted over. On the other hand, with sufficient space, mangrove forests and seagrass beds, as well as other natural habitats such as saltmarshes and the supralittoral zone with sand dunes may be able to migrate landward. Unfortunately, today, the expansion of transformed urban and agricultural land further into coastal areas has led to a coastal squeeze of these important natural habitats (Doody 2004). Consequently, in most cases the mangrove and seagrass habitats will disappear, together with a number of associated ecosystem goods and services.

Future Research Areas

As elevated sea levels, temperature, altered nutrient supply, and rainfall change at rapid rates, there is a great risk of the biogeochemical cycles (for example the water, carbon and nitrogen cycle, etc.) being altered in these natural systems. Pore-water or submarine groundwater discharge may play a major role in the exchange and export of dissolved inorganic and organic carbon (DIC and DOC), nutrient and micronutrient availability at inland bays and wetlands (Burnett et al. 2003). Understanding how these potential changes in hydrological, geochemical and biochemical processes associated with changes in climate may affect mangrove and seagrass biomass and productivity is starting to become particularly relevant (Maher et al. 2013).

Organisms have adapted to changing environments for millions of years in order to obtain a good phenotype-environmental match. However, the present environmental change in combination with global climate change is probably taking place at a higher pace than any time before, which requires a much faster response (e.g. phenotypic plasticity) from marine organisms. To develop better and more science-based coastal management procedures when, for example, allocating space for various human activities and marine protected areas (MPAs), we need to understand the adaptive capacity among different populations within species, as well as potential differences between species e.g. mangrove trees and seagrasses plant species. With a better knowledge about evolvability and adaptive capacity, it would be possible to develop models and carry out simulations in order to more accurately forecast future changes in species distribution and community changes.

Efforts need to be made to understand both current taxonomy and microevolutionary processes if we are to adequately model the specific responses of continually evolving subpopulations.

Opportunities for management and conservation

For the WIO region, it is important to remember that mangroves and seagrasses provide a wide range of coastal ecosystem services but are also highly threatened arguably by an equally extensive list of issues. This emphasizes the urgent need for improved management and a clear idea about the road forward.

Global climate change is contributing to elevated sea levels at an accelerating trend globally and is having profound effects on coastal and urban areas in all continents, and the WIO region is no exception (Ngusaru et al. 2000; Masalu 2002; Almström & Larsson 2008; Shaghude et al. 2015; Shaghude et al. 2018). In order to prevent or mitigate the impacts of coastal erosion, various methods have been tried. In most cases hard 'grey' structures such as groins and seawalls have been constructed (Shaghude et al. 2015). However, such structures may result in additional problems by shifting erosion alongshore and eventually eroding sandy beaches and dune landscapes and causing siltation in other areas. During the last few decades, various forms of "green" infrastructure have been trialled to manage coastal erosion effectively, with the added benefit of providing numerous ecosystem services (Jones et al. 2012; Duarte et al. 2013; Munang et al. 2013; Spalding et al. 2014; Temmerman et al. 2014). Mangrove vegetation and seagrass meadows are an integral part of these natural shoreline protection solutions.

One area which has lacked in-depth research previously, is the natural interactions that exist between the marine and terrestrial environment. Seashores with a diverse set of ecosystems including seagrass, mangroves as well as rich beds of different algae and coastal forests, lead to a higher diversity and larger biomass of different plants and insects in the coastal area (the supralittoral) (McLachlan & Brown, 2006). Rich shoreline and shallow water plants and algal communities create a food web that connects the marine environment with the adjacent land. It is therefore not only an exchange of sand and sediment but also a considerably exchange of particulate and dissolved organic matter when plants and algae are washed up onto land and when animals from both habitats migrate between the beach and the dunes searching for food (Defeo et al., 2009; Mellbrand et al., 2011). These synergies contribute to conserving and/or further increasing biodiversity but have been largely under-studied at local levels in the WIO.

Mangroves and seagrass beds in the WIO offer similar research-based management challenges as discussed for coral reefs and later for fish. Probably the single most important improvement to enhance the quantity and quality of research in the region would be to facilitate even stronger networks and communication among research groups across countries in the WIO. With closer interactions among researchers, knowledge transfer would improve, and research groups could agree upon standardized methods for basic field work procedures, such as harmonised sampling designs to enable comparisons between location and/or among regions. Such studies also need to be transferred, preferably to an open source regional database, where geographical coordinates together with detailed GIS maps (Geographic Information System) can be stored and viewed for any user. CORDIO's Marine Spatial Atlas for the Western Indian Ocean (<http://cordioea.net/outputs-results/maspawio/>) is a good example of how such service and interface could appear.

Fish

Key ecosystem characteristics and distribution

The coastline of the WIO is characterized by a wide diversity of habitats and biogeographic regions. The southern extent of the WIO encompasses South Africa's warm-temperate coastline. Here, habitats for fishes include salt marsh and seagrass (in estuaries) as well as rocky reefs and mixed rocky and sandy shorelines. South Africa's east coast is classified as sub-tropical and, in this region, the southernmost mangroves and coral reefs are found. This region is also the southernmost distribution limit for many tropical Indo Pacific fish species. The coastlines of northern Mozambique, Tanzania, Kenya, Somalia and the island states of Comoros, Madagascar, Reunion and Mayotte, Mauritius and Seychelles are tropical, with fringing coral reefs, extensive mangrove forests and seagrass beds. The WIO supports a diverse fish assemblage with approximately 2200 fish species

recorded (van der Elst et al. 2005; Kulbicki et al. 2013), representing 15% of the marine fishes found globally (Smith & Heemstra 1986, van der Elst et al. 2005). The variety of habitats, geomorphological histories and biogeographic regions in the WIO also gives rise to different structures of reef fish assemblages a high level of endemism, particularly off the warm-temperate coastline of South Africa, with 13% of fish species endemic to the WIO (van der Elst et al. 2005; Samoilys et al. 2019). Over 50% of the fish species here have an Indo-Pacific origin (tropical), while 29% are deep sea species, 4% cosmopolitan and 3-4% Atlantic species (van der Elst et al. 2005).

Description of benefits

The coastal zone in the WIO is rather densely populated, with an estimated three million people directly dependent on fishing for their livelihood in this region (van der Elst et al., 2005; Temple et al. 2017). Overfishing can reduce the adaptability of fish to climate variability and climate change (Hsieh et al. 2006) although very little work has been done on the impact of climate change on the fish communities of the WIO, with the most data available from South Africa (e.g. James et al., 2013, Potts et al., 2015).

A large proportion of WIO countries' population live near the coastal zone with fisheries contributing to employment and protein (van der Elst et al. 2005). Most of the fishers in the region are considered artisanal or subsistence, rather than industrialized (van der Elst et al. 2005) thus generating accurate estimates of fisheries importance is difficult but localized studies indicate their importance for livelihoods is substantial (McClanahan et al. 2015). The high reliance on fisheries resources means that the effects of climate change on fish populations can transcend resource productivity and result in serious food security and livelihood compromises (McClanahan et al. 2015, Daw et al. 2009). There is thus an urgent need to accurately predict how climate change will affect fisheries so adaptive management of the resource and the people that rely on it can be optimized (McClanahan et al. 2015).

Impacts/threats of climate change

The effects of climate change on fish populations can be either direct or indirect (Breeggemann et al. 2016). Direct effects of climate change on fish populations are physical changes in the ocean environment that influence internal patterns and processes which modulate behaviour, demographic and distribution responses (Rijnsdorp et al. 2009, Brander 2010). Changes in ocean temperature, oxygenation, and acidification are considered the three most important direct physical environmental drivers on fish populations, and responses to these stressors will determine resilience to future climate change (Gruber 2011, Pörtner 2012). Although direct effects of physical environmental drivers on fish populations can often interact (e.g., Munday et al. 2009), the overarching environmental driver is considered to be temperature because of the pervasive effect of temperature on ectotherm physiological rates which regulate performance (Holt & Jørgensen 2014, Potts et al. 2015, Hoey et al. 2016). Given that very little research has been conducted on the effects of climate change of fish and fisheries within the WIO, the impacts of climate change on the fish of the WIO can mainly be inferred from global and regional studies (Samoilys et al. 2019).

Indirect effects influence fish populations is via changes in the productivity or structure of ecosystem processes that have cascading effects throughout ecosystem networks (Brander 2010). For example, in the northern hemisphere, climate warming is changing the abundance and spatial distribution of zooplankton species in the North Sea (Helaouët & Beaugrand 2007), which in turn will exert a bottom-up effect on Atlantic cod recruitment within the same area (Beaugrand et al. 2003). In the northern Atlantic, northward movements of a number of fishes has been recorded during the last couple of decades, involving species like mackerel, herring cod etc (see e.g. Perry et al. 2005).

Studies investigating the effects of ocean acidification on fish suggest that the early life stages may be the most vulnerable to ocean acidification (Melzner et al. 2009b, Baumann et al. 2012), although some species are more tolerant than others and can emerge as "winners" (Ishimatsu et al. 2004, Munday et al. 2011). Deleterious ocean acidification responses manifest through the negative effects on growth, development, metabolism, behaviour, and ultimately, mortality and recruitment (Ishimatsu et al. 2008, Munday et al. 2010). In a pioneering ocean acidification study on a South African linefish, Erasmus (2017) and Edworthy (2017) found reduced growth, development, metabolism, and survival of post-flexion dusky kob (*Argyrosomus japonicus*) larvae at low pH

levels of 7.78 predicted for the end of the century (2100). This reduced larval performance could ultimately result in complete recruitment failure of the species if no evolutionary adaptation to low pH occurs. Direct effects of ocean acidification on subadult and adult fishes are, however, believed to be minimal as compensatory mechanisms can maintain intracellular acid-base balance in an acidic environment (e.g., Melzner et al. 2009a, Haigh et al. 2015). Low oxygen zones can also affect fish populations through reductions in available habitat or altered metabolic/physiological processes, that can ultimately result in increased mortality (Stramma et al. 2010). Temperature and oxygen are intrinsically linked in the ocean, as rising temperatures will reduce the concentration of oxygen while simultaneously increasing oxygen demand in organism tissues (Deutsch et al. 2015).

Habitat loss associated with climate change can also affect the composition of fish communities. Chabanet (2002) found that two years after the 1998 coral bleaching event, fish communities on coral reefs in Mayotte were dominated by herbivores as opposed to browsers of sessile invertebrates. An increase in the frequency and intensity of extreme events may also result in the loss of essential nursery habitats for coastal fish such as mangroves, seagrass and salt marsh (James et al. 2013). Mann and Pradervand (2007) in subtropical South Africa found a close relationship between the abundance of adult fish in the marine environment and the availability of estuarine nursery habitats, with the abundance of adults decreasing when nursery habitats were lost.

The response of fish populations to changes in ocean temperature can be broken down into four broad components; behaviour, phenology, distribution, and demography (Rijnsdorp et al. 2009, Potts et al. 2015, Poloczanska et al. 2016). Behaviour modifications are often a first response to ocean temperature changes as fish may seek to avoid unfavourable temperatures (Rijnsdorp et al. 2009). Behaviours such as swimming speed or foraging behaviour are temperature sensitive (Brownscombe et al. 2014, Johansen et al. 2014) and fish may seek temperatures that maximise these behavioural processes or adjust behaviours when temperatures are sub-optimal (Freitas et al. 2015). Temperature-induced behavioural modifications can affect fish population phenology (the timing of cyclical events), as temperature is often a cue for seasonal migrations (Sousa et al. 2016), diel migrations (Keyser et al. 2016) and spawning migrations (Sims et al. 2004). A global analysis of sea surface temperature trends by Lima and Wethey (2012) identifies the coast off South Africa as having some of the highest advances in seasonal warming. When temperature stressors are chronic over time, these short-term behavioural and phenology responses can manifest into negative impacts on the abundance and productivity of fish populations (Crozier et al. 2008).

Over longer timescales, changing ocean temperatures can drive distributional shifts in fish populations across latitudes or depths (Pecl et al. 2017). For example, Perry et al. (2005) show that nearly two-thirds of North Sea fishes responded to warming temperatures by shifting their distribution either deeper or to higher latitudes. In the warm-temperate region of South Africa, James et al. (2008) reported an increased occurrence of certain tropical fish species in temperate estuaries. Similarly, in a 19-year study of a sub-tropical reef fish community in South Africa, Llyod et al. (2012) found a general increase in the abundance of tropical species as well as a change in the proportion of tropical versus temperate species. These findings were attributed to warming of the Agulhas Current. Temperature also affects demographic processes like growth, mortality and recruitment, such that even small changes in temperature can have big impacts on population biomass and abundance (Brander 2010, Poloczanska et al. 2016). For example, temperatures that exceed the narrow thermal tolerance of fertilised eggs may lead to faster larval development, resulting in increased mortality and reduced recruitment into fisheries (Pankhurst & Munday 2011). Warming temperatures can also result in faster juvenile and adult growth rates, which alter fish production (Audzijonyte et al. 2016). Ultimately these behavioural, phenological, demographic, and distributional changes affect the abundance, productivity, and distribution of fish populations that the human population relies on for goods and services (Brander 2007).

Future Research Areas

Much of the leading work on this subject has come from South Africa, partly because of the sharp gradients in temperature facilitating detection of changes in distributions over short times and distances, as well as a longer history of studies of fish species and assemblages. Research on climate impacts on fish will require complex laboratory-based experimental studies, as well as in-situ ecological, biological and environmental data collection.

In order to generate baseline data, long-term monitoring programmes need to be initiated, particularly in data-poor counties and in areas situated at the boundary of species distributional ranges, to better assess the impacts of climate change on fish assemblages. These programmes should monitor the relative abundance of fishes as well as the stability and resilience of fish assemblages.

With a myriad of potential changes likely, an assessment of key species climate resilience, defined as the ability to resist or recover from a climate-related stressor (Côté & Darling 2010, Hodgson et al. 2015), is also a research priority. Determining fish population resilience to climate change has generally been studied through correlations between environmental variables and historical population responses (Horodysky et al. 2015). Correlative studies mostly take a “black box” approach and do not consider the underlying mechanisms that govern population responses (Helmuth 2009), which can make forecasting responses unreliable (Horodysky et al. 2015). Furthermore, assigning biological responses of populations to climate change is challenging, given the complexity of interacting mechanisms, variable species responses, and the potential of cascading effects (Poloczanska et al. 2016). While it is still useful to assess past responses to climate change, incorporating experimentally derived information on the sensitivity of underlying processes can improve inference and forecasting accuracy (Wernberg et al. 2011).

The incorporation of physiology into the assessment of vulnerability or resilience of fishes to climate change is relatively new but holds great promise as a method to develop a suite of more appropriate management tools (McKenzie et al. 2016). For example, in Papua New Guinea, Rummer et al. (2014) used metabolic physiology to identify fish species vulnerable to climate change, while Fitzgibbon et al. (2014) used metabolic physiology to identify the most vulnerable life history stage of spiny lobster (*Sagmariasus verreauxi*). Another recent global fisheries example of the incorporation of physiological research into adaptive management plans is the Fraser River sockeye salmon (*Oncorhynchus nerka*) (Patterson et al. 2016). Physiological research involved identifying the impacts of high water temperature and high river discharge in terms of thermal tolerance, energy metabolism and respiratory capacity, which among other factors, influence successful spawning migrations, and adjusting catch limits when appropriate (Clark et al. 2010, Eliason et al. 2011, 2013). In the WIO, future research quantifying the biological effect of climate change on fish populations must therefore take a species-specific process-based, physiological approach.

The way forward

We have discussed three key marine organism groups and ecosystems that are instrumental in providing important ecosystem goods and services for local communities and coastal economies in the Western Indian Ocean. To date, for these systems, there have been varied efforts in studying the different climate impacts across geographies as well as thematically in terms of the types of threats.

The current evidence suggests that temperature increases due to global warming will have the widest ranging and most immediate impact across the marine environment and is therefore justifiably the most widely studied to date, but significant investment still needs to be made on the other climate threats e.g. acidification, to understand their full effects. This will help identify and develop more holistic strategies and actions to mitigate against global climate change in the region.

Although a lot of progress has been made in the last decades, a common theme raised among all research communities, regardless of study system, is that research conducted within the WIO needs greater collaboration and partnerships amongst universities, laboratories, institutions, research groups, NGOs, and most recently the use of citizen science. This should enhance learning across and within fields and facilitate the transfer of knowledge, technology, experiences and data in order to expand the scope and number of studies. Additionally, improved standardisation of sampling designs and methodologies, in particular for studies of climate change where monitoring studies are an important part, would not only provide important baseline data, but also enable detection of minor changes in ecological communities. Increased collaboration could also help fill a key research gap on the associated or cross-effects of climate effects across ecosystems (cascading impacts).

To address the numerous research areas related to climate change and provide a comprehensive study of biological and ecological responses of organisms, the physical environment and habitat condition to these effects, a holistic and varied number of scientific techniques will be required. This includes genetic and molecular

analyses, laboratory experiments and in-situ observations. For instance, information about genetic variation within populations can provide valuable insights of species and populations uniqueness and their evolvability in order to decide if certain populations should be designated as Evolutionary Significant Units (ESU) (Conner and Hartl 2004). Currently, it would not be feasible to establish several advanced laboratories in the WIO due to the high financial and human capacity requirements. Core facilities that have the expertise and equipment to conduct advanced molecular analysis should be developed at a few key locations in WIO where the infrastructure is already relatively well developed. Exchange programs from across the WIO to these centres of excellence will enable students to learn specialist techniques e.g. molecular tools, with the aim of establishing new or progressively improving existing laboratories and research station facilities in their home countries

Finally, how ecosystems will be affected is not only dependent on the direct effects of the perturbations on individual species but also on the potential unequal pressure across trophic levels which could lead to imbalances in the trophic structure, causing trophic cascades that may change the dynamics of the ecological community (Ober 2016). If we are to fully understand the complex effects of a changing climate, this is a key area to consider.

Conclusion

The WIO has an established group of researchers in government and private research institutions working across different geographic areas and fields. There are also active regional monitoring networks e.g. GCRMN, associations like WIOMSA which can coordinate regional collaboration, as well as regional inter-governmental policy frameworks e.g. UN Nairobi Convention. The marine science sector in the WIO is therefore at a point where there is potential to significantly grow and improve with the right investment. The UN Decade of Ocean Science starting in 2020 provides a timely opportunity for this to happen. At the same time government interest and intention to invest in the Blue Economy requires complementary investment in monitoring and research of ecosystems and other resources, as climate impacts will underpin the benefits that are obtained from the ocean.

This review highlights that there will most certainly be both biological and human “winners” and “losers” in certain areas of the WIO, it is our contention that understanding, and perhaps successfully predicting, ecological responses to global climate change will be aided greatly by a deeper investment in a multitude of research areas such as field ecology, genetics and social science, as well as investing in mechanisms to increase collaboration and transfer expertise across countries, institutions and subject areas.

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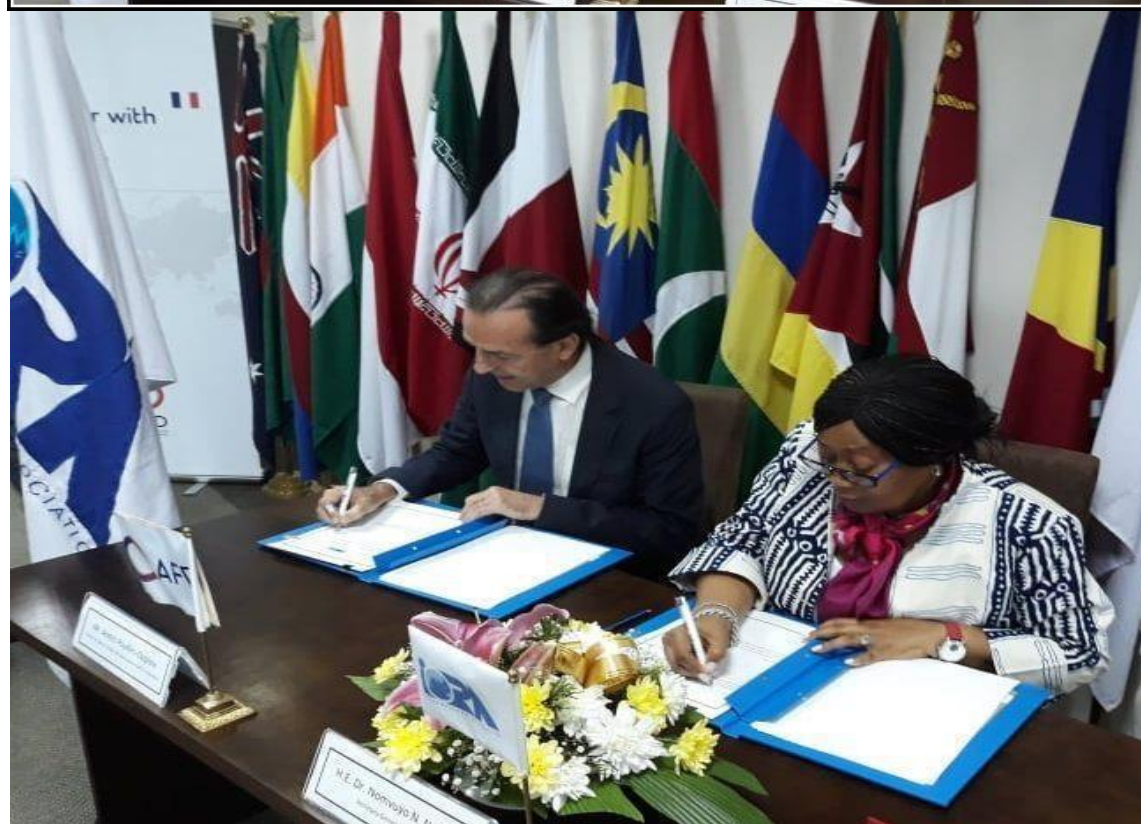
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IORA and France through the Agence Française de Développement (French Development Agency) signed a Memorandum of Understanding (MoU) on 9 March 2020 for the 'Strengthening the Capacities of IORA in Promoting the Blue Economy and Fisheries Management' project, valued at EUR1 million over three years. This project will support the implementation of IORA's Jakarta Concord and Action Plan 2017-2021.



International Women's Day

2020

IORA Secretariat

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“ Great investment opportunities exist in several economic sectors in the region. These include infrastructure development, recycling, pharmaceuticals, fisheries and aquaculture and ocean energy, amongst others. ”



H.E. Nandcoomar Bodha, Minister of Foreign Affairs, Regional Integration and International Trade

Opening Remarks by the Honourable Nandcoomar Bodha, Minister of Foreign Affairs of the Republic of Mauritius at the IORA Experts' Meeting to Enhance Intra-Regional Trade and Investment.
30 – 31 January 2020 – Mauritius



2020 Wishes from the IORA Secretariat to all
Member States and Dialogue Partners

THE IMPORTANCE OF SUSTAINABILITY FOR INNOVATIVE SOLUTIONS AIMED AT SOLVING THE POLLUTION OF THE OCEANS

A. Sortino a, S. Vacante b, A. Andò a, M. Mauro c, V. Dagostino a, G. De Leo d, F.G. Beltrame Quattrocchi a,e¹³³

ABSTRACT

A wide range of pollutions affects our oceans. Greenhouse gas emissions, plastic waste, maritime traffic and noise from deep sea mining are example of pollutants. Innovative solutions in different areas from technology, to policy, strategy system innovation and process innovation have been scientifically researched and developed. However, the concept of sustainable innovative solutions is fundamental. For example, a new technological innovation, resulting from scientific research activity, must be sustainable in itself in order to benefit the society and the environment. In this paper, we highlight three innovative and sustainable solutions capable of addressing the rapidly worsening pollution of the oceans. The first solution is a combined process and technological innovation with the goal of reducing marine pollution from plastic waste. The second is a technological innovation for the reduction of pollutants in maritime traffic and the third is a policy innovation aimed at drafting guidelines for the acoustic impact of extraction activities related to Deep Sea Mining.

Keywords: sustainability, innovation, environmental impact, pollution, deep sea mining, hydrogen, marine litter.

LIST OF ACRONYMS

BC- Blue Carbon	MH- Metal Hybrids
BE- Blue Economy	MIT- Ministry of Infrastructure and Transport
CCS- Carbon Capture and Storage	PEM-Polymer Electrolyte Membrane
ECA- Emission Control Area	SCR-Selective Catalytic Reduction
FC- Fuel Cell	SMS- Seafloor Massive Sulfide
GG- Greenhouse Gas	SOI- Sustainability Oriented Innovation
IMO- International Maritime Organization	WCED- World Commission on Environment and Development.
ISA- International Seabed Authority	

³³ a ENR - Ente Nazionale di Ricerca per la promozione e standardizzazione, Via F. Crispi, 248 - 90139, Palermo, Italy. Contacts: +39 0917439545, info@enrstandards.org.

b Centro per gli studi di Tecnica Navale CETENA S.p.A., Via I. D'Aste, 5 – 16121, Genova, Italy. Contacts: +39 0105995460, info@cetena.it.

c Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF), Università degli Studi di Palermo -, Via Archirafi, 18 - 90123 Palermo, Italy. Contacts: manuela.mauro01@unipa.it

d College of Allied Health Sciences, Augusta University, 987 St. Sebastian Way, EB 204, Augusta, Georgia - 30912, USA. Contacts: +1 7067218792, gdeleo@augusta.edu.

e Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi (DIBRIS), Università degli Studi di Genova -, Viale Causa, 13 - 16145 Genova, Italy. Contacts: +39 0103352707, francesco.beltrame@unige.it.

INTRODUCTION

Since the late 1990s, researchers have discouraged the practice of dividing pollution into categories (air, water, land) and they have stated that there is only 'one pollution' because, by traveling streams and rivers, oceans accumulate the majority of pollution we produce on land, even if we live far from the coasts. Oceans control the weather, clean the air, provide food to the world, and offer work to millions of people.

Over the past 150 years, due mainly to the continuous increasing of commercial activities around the world, the global consumption of oil, gas and coal has exponentially grown, and it is now considered the main cause of high amounts of Greenhouse Gas (GHG) emissions. These emissions have contributed to increase, in average, the temperatures around the world by 1 degree Celsius.

In 2018, the International Maritime Organization (IMO) has implemented a strategy aimed to reduce the GHG emissions from maritime traffic by at least 50% by 2050. From January 1, 2020 all ships operating outside the Emission Control Areas (ECA) will have to either use a fuel with a sulfur content of 0.5% or install on board a scrubber, a system for cleaning exhaust gases. Sulfur oxide emissions produce sulfur sulfate aerosols that increase risks to human health. Sulfur oxides, nitrogen oxides and particulate matter cause premature death, including lung cancer and cardiovascular diseases. These pollutants also contribute to acidification in terrestrial and aquatic environments (Transport Environment, 2019). Nitrogen oxides, in addition to causing acidification and eutrophication of land, lakes and seas, contribute to the formation of particles that are moved over long distances in air (Winnes, Fridell, Yaramenka, Nelissen, Faber, & Ahdour, 2016).

Every year, around 300 million tons of plastic are produced worldwide, of which only 14% is recycled, and 10% ends up in the sea. An estimated 270 thousand tons of plastic float on the surface of the oceans; in the Pacific Ocean the amount of floating plastic waste is twice the surface area of France. Plastic constitutes about 80% of the solid waste present in the seas of the world. Plastic is the main type of waste that we find on the beaches or deposited on the seabed (Galgani, Hanke, Werner, & De Vrees, 2013). Of this waste, 80% is of terrestrial origin, only 20% is due to activities taking place on the sea (Andrady, 2011).

Since the world population keeps growing, the demand for minerals and metals necessary to produce various products continues to increase. Valuable mineral deposits have been found under the floors of the oceans around the world and in the near future such deposits will need to be extracted (Rakhyun, 2017; Miller, Thompson, Johnston, & Santillo, 2018; Petersen, Krätschell, Augustin, Jamieson, Hein, & Hannington, 2016). Example of mineral deposits are: Seafloor Massive Sulfide (SMS) in Papua Nuova Guinea, cobalt-rich ferro manganic crusts which are found at seamounts worldwide with the largest deposits in the Pacific Ocean and manganese nodules on the abyssal plains, particularly in the Pacific Ocean (Miller, Thompson, Johnston, & Santillo, 2018; Petersen, Krätschell, Augustin, Jamieson, Hein, & Hannington, 2016; Hein, Mizell, Koschinsky, & Conrad, 2013). The exploitation of the floors of the oceans is managed by the International Seabed Authority (ISA), which is tasked with the writing of an international agreement, a *mining code*, before the start of the extraction activities. The goal of the code is to prevent and to reduce the impacts on biodiversity, while guaranteeing a fair distribution of benefits among the populations (Mengerink, et al., 2014).

Due the over-exploitation of nature, the environment is deteriorating. For this reason, environmental awareness has grown in society and it is considered essential for environmental sustainability. The growing concerns for exploited resources combined with environmental degradation have led to a demand for sustainability. In 1987 with the publication of the Brundtland Report of the World Commission on Environment and Development (WCED) sustainability was defined as: "*Sustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs.*"

During the last wave of economic development, human activities in the oceans have increased significantly. Nations and institutions around the world are developing new governance guidelines and laws characterized by policy integration and by a commitment to sustainability. Sustainable development is a fundamental principle in most national and international policies related to the oceans around the world. Sustainable development aims to meet the needs of the present, without compromising the possibility for future generations to see their needs respected.

Thirty years ago, the interest was mainly focused on technological change, finished products and their supply chain, current innovators draw on knowledge through networks, systems that use free innovation are part of the communities affected by the mode of operation, and innovation is done locally but with global reach (OECD, 2008). The definition of innovation is “the introduction of something new” (Merriam-Webster's collegiate dictionary, 2020). Innovation is a process of change which increases the value and heritage of knowledge. The innovative process passes through the generation of new ideas and their transformation into output. While innovation is often used as a word by itself, it is important to note that, in the absence of clarification on what type of innovation is under discussion, there is a risk that it will be ill-defined. We believe that the word innovation should not be used by itself, but it should always provide precise information on the type of innovation. Policy innovation, strategy innovation, system innovation, process innovation, technological innovation are examples of well-defined innovations.

Innovative and sustainable solutions are needed to reduce GHG emissions, manage plastic waste and regulate deep sea mining activities. Sustainable innovation is a type of innovation that is more effective, competitive, and successful at the same time. A Sustainability Oriented Innovation (SOI) is characterized by

intentional changes since in addition to economic returns it also thinks of a social and environmental value (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016). Sustainable innovative solutions are the process by which sustainability considerations (environmental, social, economic) are integrated at each step from idea generation, to research and development and marketing approach. The concept of sustainable innovative solutions is fundamental. For example, a new technological innovation, resulting from scientific research activity, must be sustainable in order to benefit the sustainability of society and the environment.

Since April 2019, Snam S.p.A., an Italian energy infrastructure company, has developed a sustainable and innovative technological solution that uses hydrogen to reduce pollution. Hydrogen is not present as a free element in nature, but it can be produced through a wide range of chemical and physical processes. Currently, three types of hydrogen are identified. Hydrogen is mainly obtained for industrial uses starting from natural gas, through a thermochemical conversion process that produces CO₂ (gray hydrogen), which will then have to be torn down. To this mode, the Carbon Capture and Storage (CCS) technology can be added to obtain decarbonised hydrogen (blue hydrogen) and the water electrolysis that allows to obtain green hydrogen using electrical energy to break down the water in hydrogen and oxygen, without CO₂ production (DNV-GL, 2019). The current share of green hydrogen in the world is only 4/5% of global hydrogen. Snam S.p.A is the first industrial actor in Europe to mix 5% green hydrogen with natural gas while maintaining the same transmission pipeline. Snam reported that by adding 5% of hydrogen to the total gas transported by the group, carbon emissions could be reduced by 2.5 million tons a year. According to a Snam-McKinsey report, hydrogen could supply up to a quarter (23%) of national energy in Italy demand by 2050 (SNAM, 2019). This growth could occur thanks to the progressive and now consolidated decrease in the cost of producing solar and wind renewable electrical energy and to a simultaneous reduction in the cost of electrolyzers. In Italy, hydrogen has great development prospects due to the significant natural potential for the production of solar and wind energy, from which it is possible to obtain green hydrogen through water electrolysis. Italy has more than 34,000 Km of existing pipelines for transmission and over 250,000 Km of existing pipelines for distribution. Hydrogen can be mixed in current pipelines.

According to a recent report by Bloomberg New Energy Finance the costs of producing green hydrogen worldwide, following the reduction of renewable energy production costs, may fall by more than 70% over the next ten years (SNAM, 2019). By increasing hydrogen production capacity and decreasing hydrogen costs, many new hydrogen technologies can be competitive against oil and gas. The greatest potential for using hydrogen concerns the transport sector (trucks, buses and trains), the residential sector (climatization) and some industrial applications (refining and processes that require high temperatures). Hydrogen can be a key driver towards sustainability and there has never been such an opportunity to progressively exploit the

potential of this colorless and odorless gas in building a safe, clean and sustainable energy mix for all consumers (IRENA, 2019).

In this paper, we highlight three new innovative and sustainable solutions capable of addressing rapidly worsening pollution of the oceans. The first solution is a combined process and technological innovation with the goal of reducing marine pollution from plastic waste. The second is a technological innovation for the reduction of pollutants in maritime traffic and the third is a policy innovation aimed at drafting guidelines for the acoustic impact of extraction activities related to Deep Sea Mining. In the next sections, we introduce the pollution problem, we describe the innovative solution and we discuss how these solutions are not only innovative but also sustainable.

A COMBINED PROCESS AND TECHNOLOGICAL INNOVATION FOR REDUCING MARINE POLLUTION FROM PLASTIC WASTE

Plastic remains in the sea for periods ranging from 20 years for a shopping bag to 600 years for a fishing net thread. The plastic waste is fractionated and degrades very slowly into smaller pieces reaching dimensions of a few millimeters. These tiny residues and microplastics are then ingested by living beings and therefore enter the food chain (Pham, et al., 2014). Some microplastics are formed directly in the sea, following the degradation of larger residues due to wind, wave, or ultraviolet rays. Others are produced by industry, such as pellets, exfoliating agents, additives to soaps, gels, toothpastes, or they are accidentally generated, for example, from tire dust or from the use and washing of synthetic clothes fibers (WWF, 2018). The millions of tons of plastic that end up in the oceans each year cause over 13 billion dollars in damage to marine ecosystems. Also included are economic losses in fishing and tourism sectors, as well as beach cleaning costs (UNEP, 2014).

Currently, there are efforts focused on reducing the use of plastics: clothes with a 70% recycled plastic component are produced, plastic bricks are being experimentally used in house construction, and asphalt surfaces are being tested using plastic instead of bitumen. Straws and glasses are being made with marine algae. Many companies are committed to use only recycled plastic in their packaging (WWF, 2018). The amount of waste brought on board while fishing is increasing daily, creating inconveniences and delays to the fishing activities. Furthermore, current laws like the ones in Italy state that the waste collected at sea when is taken to land is classified as special waste and therefore need to be disposed according to specific and costly procedures, creating serious economic damage to fishermen who may rather decide to leave the waste at sea.

The combined process and technological innovation is to transform the waste collected into a resource for both the fisherman and the community, thus transforming the fishermen from a potential source of pollution into ecological sentinels. To achieve this, an innovative technological solution is being designed with the goal of transforming plastics and other waste collected during fishing activities into reusable materials or energy gas, capable of being transformed into energy without combustion, using technology of fuel cells and recovering the CO₂ produced for industrial use in order to avoid its dispersion in the atmosphere. This type of system will be placed on board of ships capable of docking in all fishing ports of the Sicilian Region and smaller islands in Italy, while the energy produced on board will be used to generate drinking water, from desalinization, to continuously supply the smaller islands, which often suffer of natural water sources. The sustainable and innovative process begins with the transfer of the plastics and waste by the fishermen to special storage points in the various fishing ports. From these points the waste is collected by the ships that process them at sea and use part of the energy produced as propeller for the vessel itself. The solution of a self-propelled vehicle able to take the material recovered from the sea directly to the ports and able to use the energy obtained to move the vessel also has the objective of eliminating the pollution produced by land transports that otherwise need to be used for the transfer of the material to disposal centers.

There is an awareness of the problem but to achieve an acceptable balance constant work is needed on the side of all governmental competent Institutions. Obsolete regulations such as the one that in Italy considers "special waste" and the procedures and costs for the disposal of plastic that the fishermen recover in the sea really call for a sustainable update.

A TECHNOLOGICAL INNOVATION FOR THE REDUCTION OF POLLUTANTS IN MARITIME TRAFFIC

Maritime transport is responsible for 3% of global annual CO₂ emissions (Gielen & Roesch, 2019). The naval sector is one of the most difficult to decarbonize, since current fuels are low -cost refining residues (Kee, Zhu, Goodwin, 2005). There are many ways to reduce emissions from ships: engine improvements such as exhaust gas recirculation, two stage turbocharging, intelligent combustion chamber design and advanced fuel injection systems, exhaust gas post-treatment such as scrubbers or Selective Catalytic Reduction (SCR), and the use of various fuels such as low-sulfur diesel or liquefied natural gas (Millo, Bernardi, & Delneri, 2011; Burel, Taccani, & Zuliani, 2013). Among the possible alternatives, Fuel Cells (FC) are considered one of the most promising future technologies (Stambouli & Traversa, 2002). Energy production through fuel cells is an innovative technology that can reduce emissions of carbon dioxide and acid gases. Fuel cells are also known for the absence of moving mechanical parts and low noise emissions (Markowski & Pielecha, 2019). However, fuel cells have a high production cost mainly due to the high technological manufacturing process and the small production scale.

The project *TecBIA (Low Environmental Impact Technologies for the Production of Energy on Ships)* (FINCANTIERI, 2014/2020), led by Fincantieri S.p.A., aims to experimentally verify the sustainability of fuel cell technology for naval applications through the construction of a prototype of a naval vessel propelled by fuel cells with the goals of studying the scale-up of Polymer Electrolyte Membrane (PEM) fuel cell modules. The goal is to determine if fuel cells could be used for the generation of distributed energy for hotel services on board cruise ships, and to investigate the possibility of using the heat produced in the electrochemical conversion process to feed the air conditioning systems and the production of hot water on board cruise ships. Instead of having compressed gas or liquefied gas, with relative danger and criticality, hydrogen will be stored in the form of Metal Hydrides (MH). Since the hydrogen release mechanism from the cylinder is not instantaneous, batteries are needed to have a stable load of energy.

Currently there is no internationally recognized regulation for the use of hydrogen as fuel and fuel cells on board of ships. Therefore, this regulation, in accordance with internationally consolidated procedures, is being studied and drafted by the *National Institution of Italy for Standardization Research and Promotion (ENR)*. ENR, which is specifically concerned with analyzing, modifying and technically drawing up regulations, is contributing on the preparation of the documentation necessary to obtain the release of the Safety and Navigability Certificate from the Italian Authorities of competence (Italian Ministry of Infrastructure and Transport, MIT) so that the prototype a naval vessel once built can sail in Italian waters for testing purposes.

4. A POLICY INNOVATION AIMED AT DRAFTING GUIDELINES FOR THE ACOUSTIC IMPACT OF EXTRACTION ACTIVITIES

Scientists from around the world have analyzed the possible impacts of extraction activities in the oceans by classifying them as: fragmentation and loss of habitats, loss of biodiversity, changes in the structure of deep communities, production of waste materials and plumes rich in toxic elements, impacts due to artificial brightness and sediment production, water temperature changes and noise impact (Kaikkonen, Venesjärvi, & Nygård, 2018). The least studied and known impact is the acoustic pollution since the frequencies and acoustic intensities emitted by the technologies that are going to be used are not yet known (Hawkins, Pembroke, & Popper, 2015). The noise produced by human activities at sea is today already a real pollutant for which negative impacts have been reported on marine species at physical, physiological, and behavioral level (Parliament, 2008).

Several regulations, which attempt to manage and monitor environmental impacts on biodiversity, have been issued by the ISA, but the information is far to be completed and the problem of noise impact is still neglected (Christiansen, Denda, & Christiansan, 2019; Jaeckel, 2019). Before extraction activities take place at large scale, it is necessary to produce and possibly agree at international level on a technical standard that will contribute to monitor and set limits to the noise emitted with the goal of reducing the envisaged damage on marine ecosystems. Currently there is no single and well-defined protocol for measuring the level of marine noise pollution (André, et al., 2011).

ENR has carried out an Innovative Industrialization project (MIUR, 2014-2020) which supported the writing of the first technical standard on the acoustic impact of marine-maritime activities related to Deep Sea Mining, indicating the possible minimum criteria of acceptability (ENR, 2019). The drafting of the standard took into consideration the different conclusions existing today between the scientific results obtained on field and the laboratory experiments (Vazzana, et al., 2020). The standard provides recommendations for the management of the acoustic impact to be implemented in all operational phases of the extraction. The standard allows the management of mineral extraction activities from the ocean depths protecting as much as possible the life of the deep ecosystems ensuring a balance between exploitation of resources and the protection of biodiversity. In the proposed standard, the difficulty of evaluating acoustic impacts was taken into consideration together with the high variability and interaction with various environmental aspects. The standard has been created with the vision that it should be modified, improved, and updated when new data become available.

5. BLUE ECONOMY AND BLUE CARBON

Seas and oceans are huge renewable energy sources. Development activities and research programs by the European Commission focus on technologies in the field of ocean energy to exploit the potential of the tides, wave motion, differences in temperature and salinity. The Blue Economy (BE) covers all economic activities related to the oceans, seas, and coasts, taking into consideration both sectors that are actively contributing today and emerging and innovative sectors, which show a high potential for future development. At the base of the Blue Economy is the need for maritime economic development that leads to an improvement in human well-being and social equity, while simultaneously reducing environmental risks and ecological deficiencies, contributing to Europe's decarbonisation objectives set for 2050.

Globally the Blue Economy is currently valued at USD \$1.5 trillion (2.5% of the world's gross value added) and employs 31 million people. By 2030, it is expected to increase to USD \$3 trillion, with growth driven primarily by aquaculture, fish processing, offshore wind, shipbuilding, and repair (Steven, Mathew, & Bohler-Muller, 2019).

The sectors currently contributing to it are fishing, aquaculture, fish processing, maritime oil and gas extraction, port activities, shipbuilding, maritime transport, coastal tourism. The emerging sectors include energy from waves and tides, off shore wind production, mining in the seabed, carbon capture & storage, desalination, integrated maritime surveillance, use of the potential of marine organisms for the medical, pharmaceutical, food sector and energy production, especially algae biomass energy.

Sustainable development is the strength of the Blue Economy, which intends to take care of its assets and exhaustible natural reserves, with economic growth that respects the environment and its limits. With the Blue Economy, the EU has the objective of eliminating CO₂ emissions by contributing to economic growth through innovation and the use of sources from renewable energy and creating new jobs. The Blue Economy is also seen as the development of the Green Economy, as the latter provides for the reduction of CO₂, while the blue economy aims at zeroing CO₂. The Blue Economy represents a valuable investment both in the short and long term and at different levels: economic, social and environmental (Attri & Bohler-Muller, 2018). From an environmental point of view, carbon emissions will be reduced thanks to the promotion of long-term sustainable growth and the enhancement of the protection of the sea, land and fresh water which otherwise would quickly become increasingly scarce and expensive resources.

Blue Carbon (BC) is carbon stored in coastal and marine ecosystems, including mangrove forests, tidal, seagrass meadows, marshes. It is captured by the world's oceans and coastal ecosystems, unlike the green carbon that is stored by forests and their soils and stored in the form of sediment and biomass. These ecosystems trap large quantities of carbon by capturing it from carbon dioxide in the atmosphere and storing it for millions of years in plant sediments that are found underwater. Carbon dioxide is one of the main factors that contribute negatively to climate change.

Although these ecosystems are much smaller in size than the world's forests, they sequester carbon faster and can continue to sequester it for many years. When these ecosystems are damaged, their destruction poses a high risk. In fact, when these ecosystems are damaged, not only their sequestering capacity is destroyed, but the carbon already stored is released into the atmosphere. This contributes to the increase of gas levels in the

atmosphere. Therefore, protecting the coastal ecosystem is a great way to slow down climate change by preventing the emission of stored carbon and protecting the coastal environment (Macreadie, et al., 2019).

The International Blue Carbon Initiative is a program focused on the mitigation of climate change through the conservation and restoration of coastal and marine ecosystems. Blue Carbon satisfies all three essential elements of sustainability: economic, social, and environmental, therefore it can be considered an essential component of the Blue Economy. Blue Carbon, together with the renewable energy sector and the carbon capture and storage industries, can be considered to contribute to the development of low carbon economies.

6. CONCLUSION

In the upcoming decades, the world will face a complex challenge: to continue to grow economically while reducing CO₂ emissions. Hydrogen can be a key driver towards sustainability of innovative solutions and there has never been such an opportunity to exploit the potential of this colorless and odorless gas in building a safe, clean, and sustainable energy mix for all consumers. Hydrogen can act simultaneously as a source of clean energy and as an energy carrier for storage.

Plastic makes up about 80% of the solid waste present in the seas of the world and the main type of waste that we find on beach or deposited on the seabed. The oceans, seas and marine resources must be preserved and used in a sustainable way. A sustainable process is fundamental: the waste collected by fishermen must be transformed from a problem into a resource, both for the fisherman and the community. Time constants must be properly considered and pursued in order to propose and complete gradual but effective steps. An immediate dream may result into irreversible damage rather than progressively growing improvements.

Recent IMO regulations introduced for the protection of the environment and health aims at reducing greenhouse gas emissions (CO₂ and CH₄), NO_x, SO_x and particulate matter. For this reason, a valid alternative to traditional fuels is needed and the trend of requests for eco-sustainable ships is constantly growing. Among the possible alternatives to reduce emission levels from ships fuel cells are considered one of the most promising future sustainable and innovative technologies.

In view of the rapid growth of the world population, the resources available from land mines are running out and new deposits have been found in the ocean depths. In the immediate future, mineral extraction from the deep sea will become a reality in front of the lack of land equivalent resources. The noise produced by human activities at sea is today already a real pollutant and, for this reason, it is essential to issue guidelines and standardization rules to reduce damage to marine ecosystems in view of sustainability.

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ANALYSIS OF TRADE LIBERALIZATION OF THE BLUE ECONOMY IN INDIAN OCEAN RIM ASSOCIATION

Somya Mathur³⁴ and Badri G. Narayanan^{35 3637}

Abstract

While several studies have been done on Blue Economy, there has been none on the trade liberalization, focusing on the sectors pertaining to the Blue Economy, in Indian Ocean Rim Association which comprises of 22 member countries. In this paper, we attempt to capture the impact of the global trade, its input output linkages and the subsequent economic behavior in the Blue Economy. This would help in understanding whether the objectives of enhanced economic growth and employment opportunities can be attained through trade liberalization. The paper studies this aspect using simulations of Computational General Equilibrium analysis. The results suggest that exports, imports and GDP may increase due to the trade liberalization between IORA and non-IORA countries in the blue economy sectors. Non-tariff barrier reductions may have much more profound effect compared to tariff reductions. Both of these measures act positively by increased access to global markets in order to utilize the abundantly available Blue Economy resources. GDP expansion can be as high as half a percent of initial GDP in some countries in the non-tariff barriers removal scenario, while it is usually small in the tariff cut scenario. Trade impact is much more visible in both scenarios across the world. Therefore, for the growth of Blue Economy, trade liberalization measures may be undertaken for the promotion of economic growth and welfare of the region.

Key Words: Blue Economy, International Trade, GTAP, CGE, Economic Modelling

INTRODUCTION

As an economy grows, the priorities are not just limited to its own growth or human development but also towards environmental sustainability. Irreversible environmental degradation has happened over the centuries, with the quest of the mankind to achieve their own personal greed. Oceans which comprises of more than 70 percent of Earth's surface have also not been left unscathed. Natural events such as global climate change, pollution, and even industrial fishing in large quantities have quite a large negative impact

³⁴ Senior Economist, Infinite Sum Modelling LLC, USA and India.

³⁵ Founder and Director, Infinite Sum Modelling LLC, USA and India. Corresponding Author; Email: badri@infisum.com

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on the ocean. As toxic and biodegradable waste makes its way into our oceans, fish, corals, and other types of wildlife, it eventually makes its way into the human bodies as well.

In order to address this issue, the concept of 'blue economy' came into being, which is promotion of ocean ecology in coherence with economic development. In the most general of definitions, a blue economy seeks to promote economic growth while prioritizing the preservation and sustainability of the ocean. Groups and associations all over the world have held meetings and conferences discussing the implementation of a blue economy. Many have created so-called pillars of a blue economy, exemplifying its importance for both the ocean itself and for the people. These pillars include things like fisheries, trade and shipping, tourism, ocean energy, biotechnology, as well as new technologies such as renewable energy and aquaculture.

Indian Ocean comprises of 14.4 percent of the earth's surface and the region has some major emerging and developed economies. Geo-politically it is a key strategic basin, which has a share of nearly 12% of the World trade and 'commands control of major sea-lanes carrying half of the world's container ships, one third of the world's bulk cargo traffic and two thirds of the world's oil shipments, the Indian Ocean remains an important lifeline to international trade and transport.'

The Indian Ocean Rim Association (IORA), has promoted the concept of 'Blue Economy' in the Indian Ocean region, by promoting trade and cooperation amongst its member countries. In 2014, the IORA found that a blue economy could generate employment and food security, help in poverty alleviation and ensuring sustainability in business and economic models in the region. The IORA adopted the Blue Economy Declaration at the first Ministerial Blue Economy Conference in 2015 (IORA). The goal of this declaration was to generate jobs, economic growth, and promoting environmental sustainability, by preserving the ocean and its resources wisely. At the second Ministerial Blue Economy Conference in Jakarta, Indonesia, the need for developing innovative financial tools to enhance the Blue Economy in the IORA states was highlighted. The Blue Economy Working Group (WGBE) is part of the 2017-2021 plan of implementing a Blue Economy. The IORA priority areas concerning a blue economy are; fisheries and aquaculture, renewable ocean energy, seaports and shipping, offshore hydrocarbons and seabed minerals, marine biotechnology, research and development, and tourism. An important aspect of the blue economy is enhancing growth and employment opportunities while promoting innovation of existing technologies and strengthening the relationship between the member countries.

In this paper, we attempt to capture the impact of the global trade, its input output linkages and the subsequent economic behavior in the Blue Economy. This would help in understanding whether the objectives of enhanced economic growth and employment opportunities can be attained through trade liberalization. As there has been no comprehensive study on this aspect so far, this paper attempts to fill this gap.

LITERATURE REVIEW

Much of the literature highlights the benefits of a blue economy, especially in terms of employment growth, slowing climate change, and sustainability for fisheries. It emphasizes what may take to achieve a blue economy, and the challenges and investments that may be necessary to implement the policy. Research highlights what few countries and associations have successfully implemented policy towards a blue economy, how far along they are in the process, and what kinds of work remains to be done in order to move in that direction, but often does not show accurate or complete results of the process.

Countries that have already implemented a Blue Economy, Europe for example, see vast amounts of growth and sustainability in their economies, especially in employment. The European Union proposed a "Blue

Growth” strategy in 2012, implementing different initiatives and policies related to the sustainability of their oceans (UNEP, 2012). This includes the Blue Economy Innovation plan, proposed in 2014, with a goal of developing sustainable jobs and growth, providing knowledge and security, and cooperation between countries. One component of a blue economy, such as trade, can vastly grow seaborne trade and strengthen international relations (Sadally, 2018). Seafood is one of the most highly traded foods in the world with an extremely high export value compared to other highly traded goods (World Bank Group, 2016). This is only one example of one very important good that comes straight from the ocean that it is traded through. Another important aspect of a blue economy would be to reverse unfair trade. The island states rely heavily on Exclusive Economic Zones, or zones that only certain states can utilize and use marine resources from (CIEL). Often this is overlooked, and a key aspect is to promote fair trade for these developing countries.

Over 80% of trade all over the world is done by the sea, and the majority of it is done by developing countries (UNEP, 2012). Food and other goods are most often transported through oceans, fish being the largest single trade item for developing countries (UNCSD, 2012). As trade is projected to grow at record numbers in the near future, it is highly important to consider the sustainability of trade and its effect on pollution, highlighting the importance of a blue economy for trade, as trade is important for ocean growth (The Ocean Foundation). Reducing greenhouse gas emissions, pollution, creating more possibility of trade and therefore creating opportunity for employment are all benefits of implementing a blue economy. It is also important to consider that as trade grows, coastal countries must be able to cater to it in the most efficient way possible and take advantage of it.

Key opportunities for growth in trade in the ocean is directly related to consumption of seafood products, including an increase in the demand for food and cosmetic and pharmaceutical products (World Bank and United Nations Department of Economic and Social Affairs, 2017). Other maritime transport industries, international regulations, and demand for general transport are key drivers in the growth of a blue economy as related to trade.

The table below highlights what quantitative studies have been recorded related to a blue economy. These highlight the importance of prioritizing sustainability for our oceans, as it may stimulate major economic growth as well as have long-term benefits relating to the wellbeing of the oceans and of the people. Most quantitative studies do not specifically involve trade and commerce between countries or around the world.

Table 1: Literature Review

Study Topic	Objective	Methodology	Broad Results/ Conclusions

Enhancing Economic Sustainability in Bangladesh (Sarker et al., 2018)	Evaluate the economic potential, identify challenges, and develop a framework for a blue economy	Consulting stakeholders related to blue growth, reviewing policy documents and scholarly articles	Climate events are the biggest challenge of a blue economy. Fishery, tourism, trade and sea commerce have large potential. Bangladesh lacks any strategic planning to make blue growth happen
Estimating the Impact of - Ecological Restoration Economy (BenDor et al., 2015)	Estimate the number of jobs and economic growth that stems from restoration economy	Survey of businesses that participate in restoration work	Ecological restoration provides over 200,000 jobs and \$25 billion of economic output yearly
Evaluating Marine Exploitation Activities in China (Cao et al., 2020)	Screen exploitation activities to find which are suitable for development of the marine economy and ecological environment	An evaluation index system consisting of economic benefit, social benefit, resource depletion, and environmental cost for seven types of marine exploitation activities	Coastal industry and urban construction have the highest benefits, while open and enclosed marine culture have the least
Uncovering the Blue Economy in Coral Reef Fisheries (Grafeld et al., 2017)	Assess the value of coral reef fisheries in the ocean and conservation efforts	Value and supply chain assessment with valuation of monetary and non-monetary benefits, stakeholder interviews, and literature review	Sustainable management is necessary even for small scale fisheries as they generate over \$10 million annually, 7 million meals, and much trade
Marine Resource Congestion in China (Liu et al., 2020)	Examine how excessive use of marine resources restricts output efficiency and sustainability.	Index system to evaluate use of marine inputs, rating spatiotemporal evolution and inefficiency.	Long-term marine resource congestion is affected by input of resource and capital and industrial structure, leading to inefficiencies like resource congestion and long-term technicalities.

Future Impacts of Climate Change on Fisheries (Blasiak et al., 2017)	Examine the effects of climate change on fisheries, determine which countries are at highest risk.	Calculate a vulnerability index of 147 countries, aggregating for exposure, sensitivity, and adaptive capacity.	The least developed countries are the most vulnerable to climate change, as they are less able to adapt. A negative correlation exists between vulnerability and per-capita carbon emissions.
Assessing the Economic Impact of the Proposed "Indian Ocean Rim-Association for Regional Cooperation (IORARC)" Preferential Trade Agreement (Mohammad Masudur Rahman et al. 2014)	Investigate the economic impact of the preferential agreement.	The Computable General Equilibrium Analysis is used to simulate the scenarios when tariff is eliminated in high income group countries of IORA, tariffs are cut by 75% in middle income countries and by 50% in low income countries of IORA.	When there is complete tariff elimination by high income countries and reduction in tariffs in middle- and low-income countries then all countries of IORA except Madagascar could gain welfare significantly.

METHODOLOGY AND DATA

This paper uses GTAP database version 10.A and the standard GTAP model (Hertel, 1997) to analyze welfare, macroeconomic and trade impacts. The Computable General Equilibrium modeling framework of the Global Trade Analysis Project (GTAP) has been used to explore the impacts of trade liberalization on IORA countries for the expansion of Blue Economy. A GTAP Model is a multi-region, multisector, computable general equilibrium model, with perfect competition. GTAP helps in run simulations interactively in a Windows environment using the GTAP general equilibrium model. Results and complementary information for the analysis were provided in a Windows environment and were accessed.

MODEL STRUCTURE

The standard GTAP Model has been used to analyze trade liberalization impacts. Version 10A of the GTAP database covers 65 disaggregated sectors, 141 regions/countries and 5 factors of production, which are aggregated into appropriate version for the simulations.

In the model, the economies are aggregated into 15 sectors and 31 countries/regions, of which 20 regions are the IORA economies. The 31 regions are a mix of all 22 IORA countries and some non-IORA regions. The regions and their codes are given in Table 2.

Table 2: Countries included in the Model and their codes

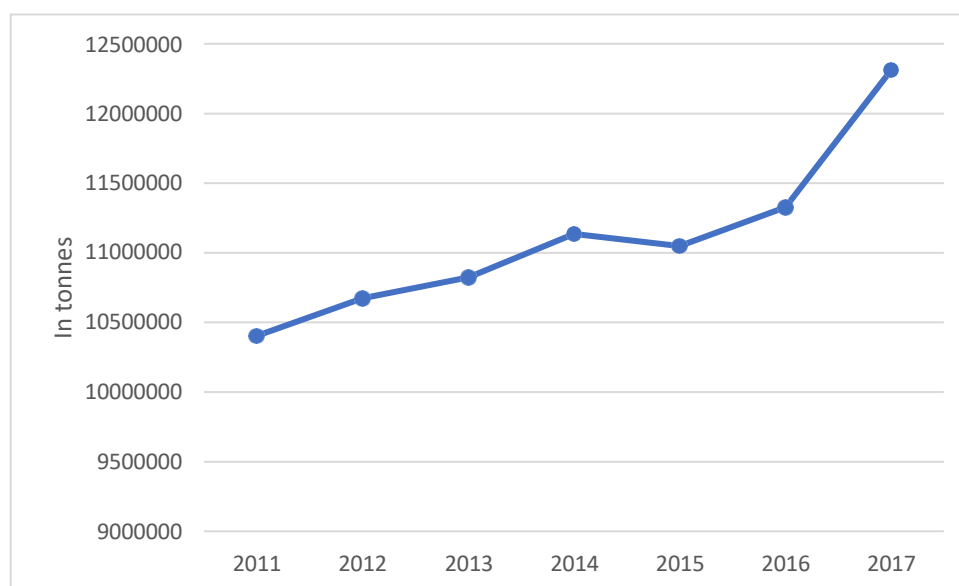
Sl. No.	Code	Region Description
1	aus	Australia
2	idn	Indonesia
3	mys	Malaysia
4	sgp	Singapore
5	tha	Thailand
6	bgd	Bangladesh
7	ind	India
8	lka	Sri Lanka
9	xsa	Rest of South Asia (to include Maldives)
10	ken	Kenya
11	mdg	Madagascar
12	mus	Mauritius
13	moz	Mozambique
14	zaf	South Africa
15	tza	Tanzania
16	xec	Rest of Eastern Africa (to include Somalia and Seychelles)
17	xsc	Rest of South African Customs (to include Comoros)
18	irn	Iran Islamic Republic of
19	omn	Oman
20	are	United Arab Emirates
21	xtw	Rest of the World (to include Yemen)

Table 3: Sectors included in the Model and their codes

Sl. No.	Code	Sector Description
1.	Ofd	Food products nec
2.	Fsh	Fishing
3.	Wtp	Sea transport
4.	Osg	PubAdmin/Defence/Health/Educat
5.	Ros	Recreation and other services
6.	GrainsCrops	Grains and Crops
7.	MeatLstk	Livestock and Meat Products
8.	Extraction	Mining and Extraction
9.	ProcFood	Processed Food
10.	TextWapp	Textiles and Clothing
11.	LightMnfc	Light Manufacturing
12.	HeavyMnfc	Heavy Manufacturing
13.	Util_Cons	Utilities and Construction
14.	TransComm	Transport and Communication
15.	OthServices	Other Services

Table 3 gives details of all the sectors included in the model. The sectors included in the model are those which are incognizance to the objectives of the Blue Economy of IORA to promote economic growth, generate employment opportunities while conserving the Ocean and its resources. Some other sectors have also been included in the model to know the impact on them due to trade liberalization in some of the key sectors of the blue economy.

Figure 1: Capture fish production in Indian Ocean



Source: FAO, Fisheries and Aquaculture Department

Fish is the vital resource of this region. As per FAO Fisheries and Aquaculture Statistics, Indian Ocean region's share is 13.32% in capture fish production of the world in 2017 as shown in the figure above. It is a key source of livelihood and food security. Under the Blue Economy it is crucial to conserve this resource from depletion due to illegal, unreported and unregulated fishing, climate change and pollution. Development of fisheries and sea food product industry can contribute to food security, job creation, income generation and poverty alleviation. In the paper we have simulated the impact of trade liberalization in fisheries and sea food product industry. Fisheries is coded as 'fsh' and sea food product industry is coded as 'ofd'.

'The Indian Ocean as a major transit area for international trade is evident in the fact that half of the world's container ships, one third of the world's bulk cargo traffic and two thirds of the world's oil shipments cross its waters annually'. Hence, it's important to develop sea borne transport sector for the development of the region. For this reason, we have included water transport in our model structure and coded it as 'wtp'. Another key priority area of IORA is promoting maritime safety and security among member states from pirates, terrorism, weapon trafficking, IUU fishing, unlawful exploitation of marine resources and climate change. The defense sector comes under public administration in GTAP model, which is coded as 'osg'. Similarly, Education is also included in the 'osg' code, as IORA's objective is also to foster cooperation among the member states and their respective academia to scientific research and enhanced technologies. The region comprises of beautiful island nations and littoral countries, hence boosting tourism is also one the priority area of the regional association. Recreational and other services coded as 'ros' and accommodation and restaurants (afs) have also been included in the scenarios.

Tariffs are custom duties, which are levied on the imports of a country. They thus make the imports expensive and give a price advantage to the locally produced goods over similar goods which are imported. They also raise the revenues for the governments. In contrast to these direct measures, there are some indirect policy measures that can create bureaucratic or legal barriers in the flow of goods, such as unjustified sanitary and phytosanitary measures, general or product specific quotas, import licenses, export

subsidies, quality conditions imposed on the imported goods, etc. These indirect measures are called Non-Tariff Barriers.

The commercial shocks have been simulated in the form of elimination of tariffs and reduction in non-tariff barriers on the key priority areas of IORA, which are promotion of fisheries and sea food product industry, boosting tourism and regional cooperation in scientific research, ensuring Maritime safety and security and development of water transport.

The rest of the sectors as given in Table 3, have been included to know the transmission of impact of trade liberalization in key priority sectors of Blue Economy in IORA.

RESULTS:

Using the GTAP analysis, we have simulated the commercial shocks in the form of the following two scenarios:

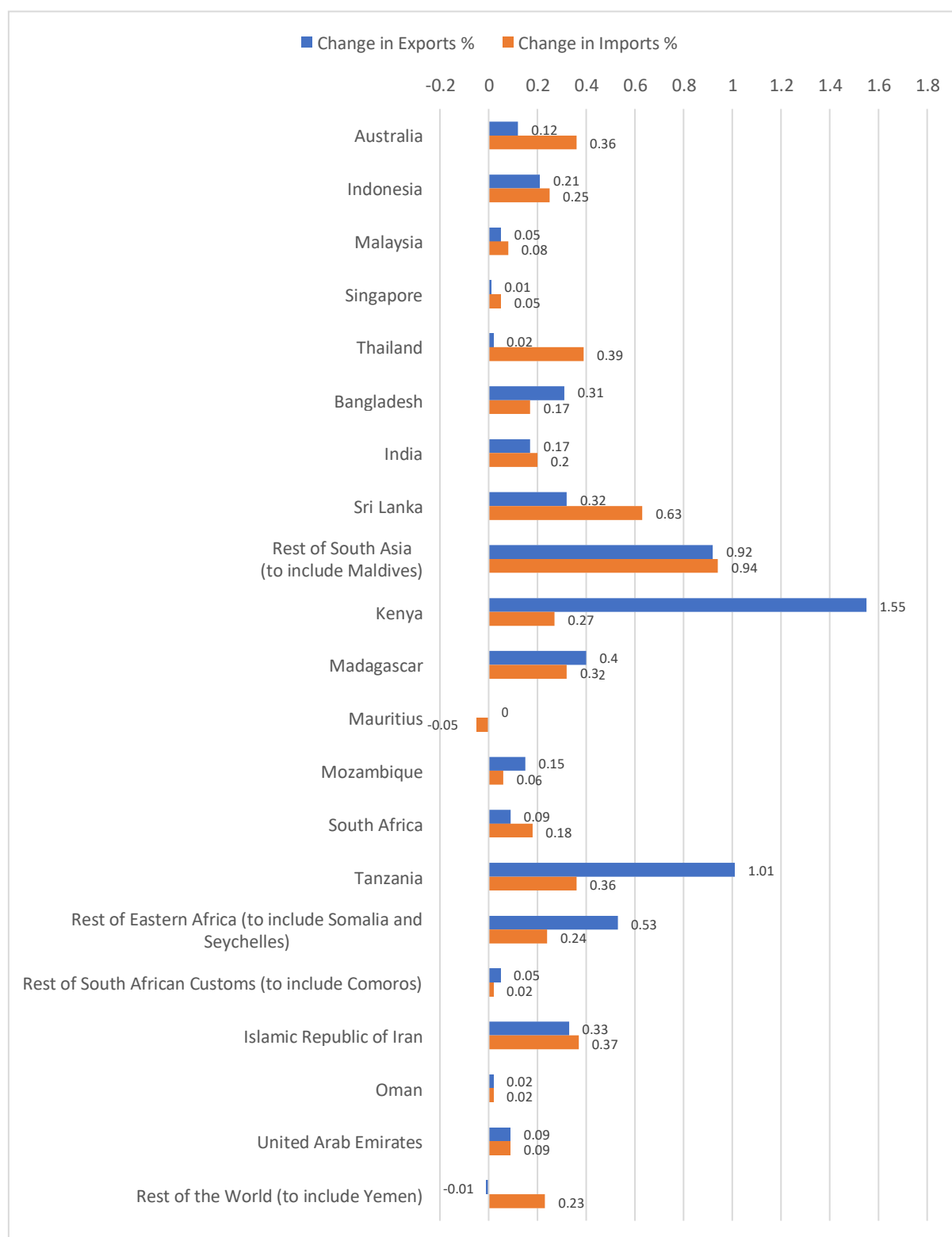
1. Complete elimination of tariffs:
In this scenario we assume that bilateral tariffs have been eliminated on the fisheries and sea food products sector, which is one of the priority sectors of the Indian Ocean Rim Association member countries.
2. Reduction on Non-tariff barriers on tourism, defense, education and water transport sectors:
In this scenario non-tariff barriers are reduced for sectors such as sea borne transport, tourism, education, defense, accommodation and food services etc. in the IORA member countries.

SCENARIO I:

The first scenario is to complete elimination of tariffs on fisheries and sea food products in IORA nations. The impact of this commercial shock on the macro variables has been simulated in our model.

The elimination of bilateral tariffs on import of fisheries and sea food products by IORA countries from other regions of the world, may lower the prices of fisheries and fish food products. Domestic consumers may immediately substitute away from competing imports, thereby increasing the aggregate demand for imports. The composite price of imports of other sectors may also fall. Thereby the aggregate demand for imports in IORA may increase. The simulated result is reflected in Figure 2 where the imports are seen to rise for most of the regions.

Figure 2: Change of Exports and Imports due to Tariff elimination (in %)



Cheaper imports may serve to lower composite price of intermediate products, which may cause excess profits at current prices. This in turn may induces output to expand, which in turn may generate an expansion effect. This is reflected in Table 4 generated out of the model simulation. We notice that there is an increase in industry wise output in Fisheries and Food Products and many other sectors.

The expansion effect may induce excess demand for factors of production. Since we are assuming full employment in this general equilibrium model, the excess demand may bid up the prices of the mobile endowments. This phenomenon may be transmitted to other sectors as well. Thereby this may create increased efficiencies in factors of production as they now may have to compete with competitive foreign products. Inter sectoral transfers of factors of production may also take place. These conditions may lead to increased efficiencies of factors of production. In addition, economic benefits may expand dynamically through capital formation mechanisms and productivity improvements. There may be an expansion of production, higher consumption and more capital investments (as reflected in Figure 6). There may be an overall increase in income and welfare as reflected in Figure 3 and 4. However the expansion phase in these economies due to elimination of tariffs may be offset by adverse terms of trade effects and trade diversion effects. Due to this we notice only a marginal increase in the GDP of these countries. Figure 3 indicates the highest GDP rise is of Maldives with 0.6% increase in its GDP (US\$ 14.79 Million), followed by Thailand with 0.4% increase (US\$ 144 Million) and Tanzania by 0.4% (US\$ 20.86 Million). Iran is an exception with a decline in its GDP by 0.6% which is US\$ 255.22 Million.

Table 4: Change in Industrial output of the Sectors in the regions due to Tariff

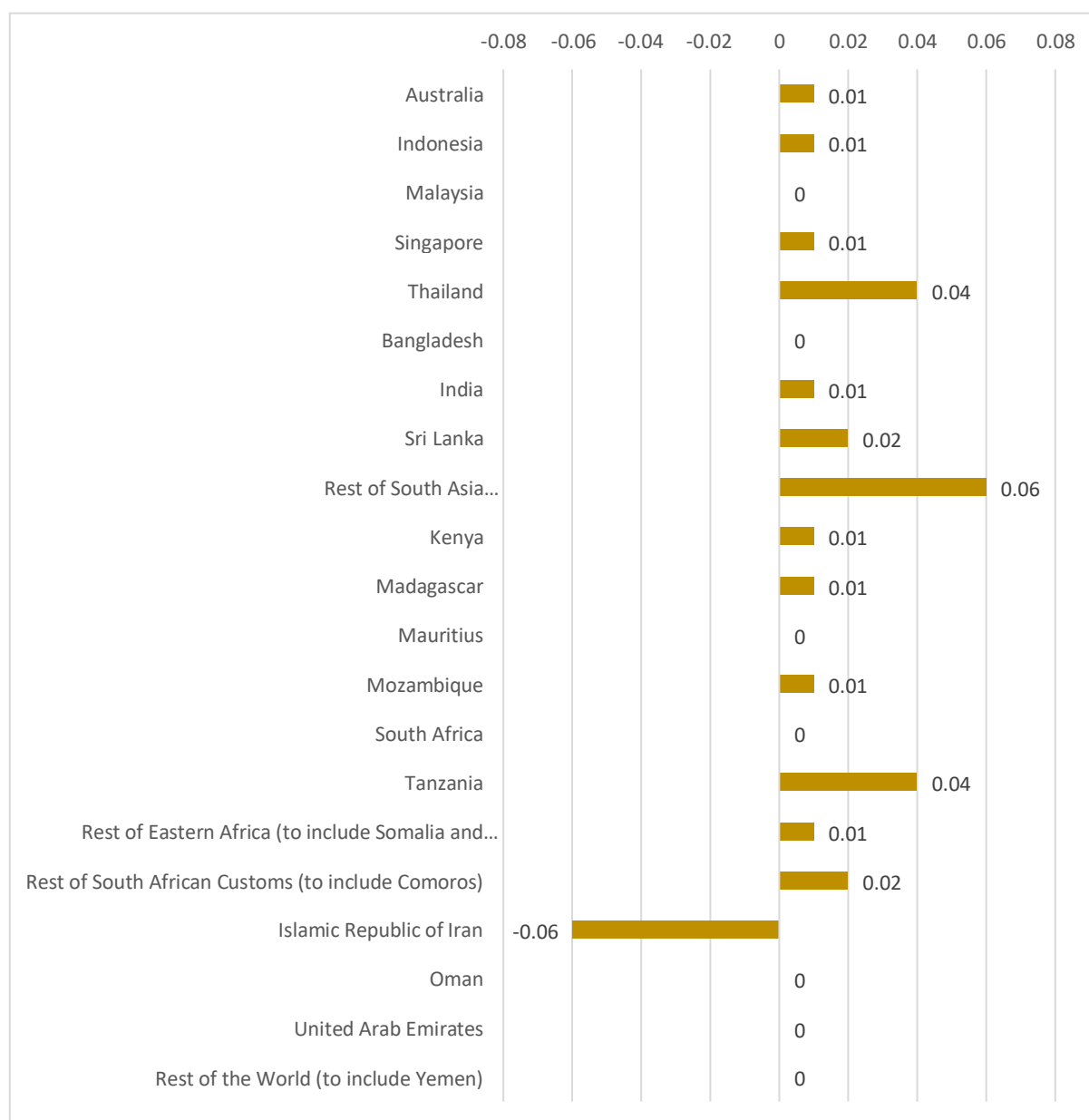
Elimination (in %)

Region	Grain s Crop s	Meat Live stock	Fish	Mini ng & Extr action	Food Pro ducts	Proc essed Food	Text iles & Clot hing	Ligh t Man ufac .	Heav y Man ufac.	Utili ties & Con str.	Wat er Tran spor t	Air Tran spor t	Tran sp & Com m.	Pu bli c Ad mi n	Rec reati on	Oth er Ser vices	Ac co m Fo od	Ed uca tio n	Heal thca re	CGD S
Australia	0.02	-0.44	1.06	-0.2	4.98	0.07	-0.47	0.29	-0.47	0.06	0.16	0.24	0.03	-0.01	-0.07	-0.01	-0.02	-0.05	-0.02	0.12
Indonesia	0.02	0.14	0.18	-0.04	0.52	-0.07	0.16	0.07	-0.08	0.01	0.03	0.02	0.01	-0.01	-0.01	0.00	0.02	-0.02	-0.01	0.02
Malaysia	0.02	0.62	0.52	-0.04	5.28	-0.21	0.31	0.13	-0.22	0.01	0.06	0.06	0.00	-0.02	-0.06	-0.03	-0.02	-0.01	0.02	0.04
Singapore	0.09	0.08	0.04	-0.08	18.6	1.52	0.37	0.27	-0.2	0.03	0.03	0.02	0.06	-0.03	-0.02	-0.13	-0.04	-0.03	0.00	0.03
Thailand	0.29	-0.58	3.41	-0.3	12.1	0.06	-1.0	0.76	-0.61	0.34	0.28	0.56	0.06	-0.09	-0.07	-0.18	-0.01	-0.01	0.09	0.53
Bangladesh	0.00	-0.01	-0.17	0.02	1.36	0.03	0.23	0.14	0.09	0.04	0.04	0.02	0.01	-0.05	0.00	0.00	-0.02	-0.03	-0.02	-0.03
India	0.11	-0.04	0.23	-0.04	1.13	0.06	-0.13	0.07	-0.06	0.01	0.01	0.07	0.00	0.00	-0.03	-0.04	-0.02	0.00	0.01	0.02
Sri Lanka	0.07	0.21	0.48	-0.53	3.6	-0.09	-1.37	0.92	-0.58	0.15	0.56	0.04	0.03	-0.03	0.08	-0.16	-0.13	-0.02	0.05	0.26

Rest of South Asia (to include Maldives)	0.1	-0.02	0.87	-0.39	8.77	-0.1	-0.4	-0.44	-0.59	-0.07	-0.26	-0.32	-0.12	-0.05	-0.08	-0.18	0.07	-0.13	0	0.4
Kenya	0.1	-0.11	-0.07	0.37	-0.8	0.02	0.62	0.82	0.74	0	0.29	0.38	0.11	-0.11	-0.05	0.05	0.08	0.03	0.12	-0.1
Madagascar	0.08	-0.08	-0.09	0.1	-3.06	-0.04	0.51	0.14	0.22	-0.01	0.08	0.12	0.03	-0.12	0.13	0.06	0.55	-0.1	-0.11	-0.12
Mauritius	-0.03	0.02	-0.03	0.02	-0.41	-0.01	0.1	0.05	0.09	-0.04	0.08	0.01	0.02	-0.01	0.03	0.02	0	0	-0.01	-0.05
Mozambique	0.04	0.03	-0.03	0.03	-3.15	0	0.13	0.21	0.15	0.06	0.05	0.02	0	-0.11	0.04	0.05	0.27	-0.07	0.03	-0.03
South Africa	0.16	0.01	1.86	-0.05	1.89	0.01	-0.11	-0.12	-0.19	0.02	-0.05	-0.08	0	0	0	0	0	-0.02	0	0.09
Tanzania	-0.14	0.09	-0.07	0.3	-2.21	0.21	0.76	0.47	0.74	-0.05	0.05	0.09	0.08	-0.07	0.27	0.05	0.18	-0.03	-0.05	-0.08
Rest of Eastern Africa	-0.01	0.51	-0.23	0.12	-3.89	0.08	0.27	0.23	0.4	-0.07	0.07	0.18	0	-0.06	0.03	0	0.1	0.06	-0.06	-0.12
Rest of South African Customs	0.05	0.04	0.04	-0.01	0.04	0.01	-0.01	0.01	0	-0.03	0.01	0.01	0	-0.02	0.01	0.01	0.03	-0.02	-0.01	-0.02
Islamic Republic of Iran	0.02	-0.01	-0.05	0.05	-0.43	0	0.09	0.08	0.04	-0.01	0.1	0.07	-0.01	-0.06	-0.01	0.01	0.06	-0.03	-0.06	-0.05

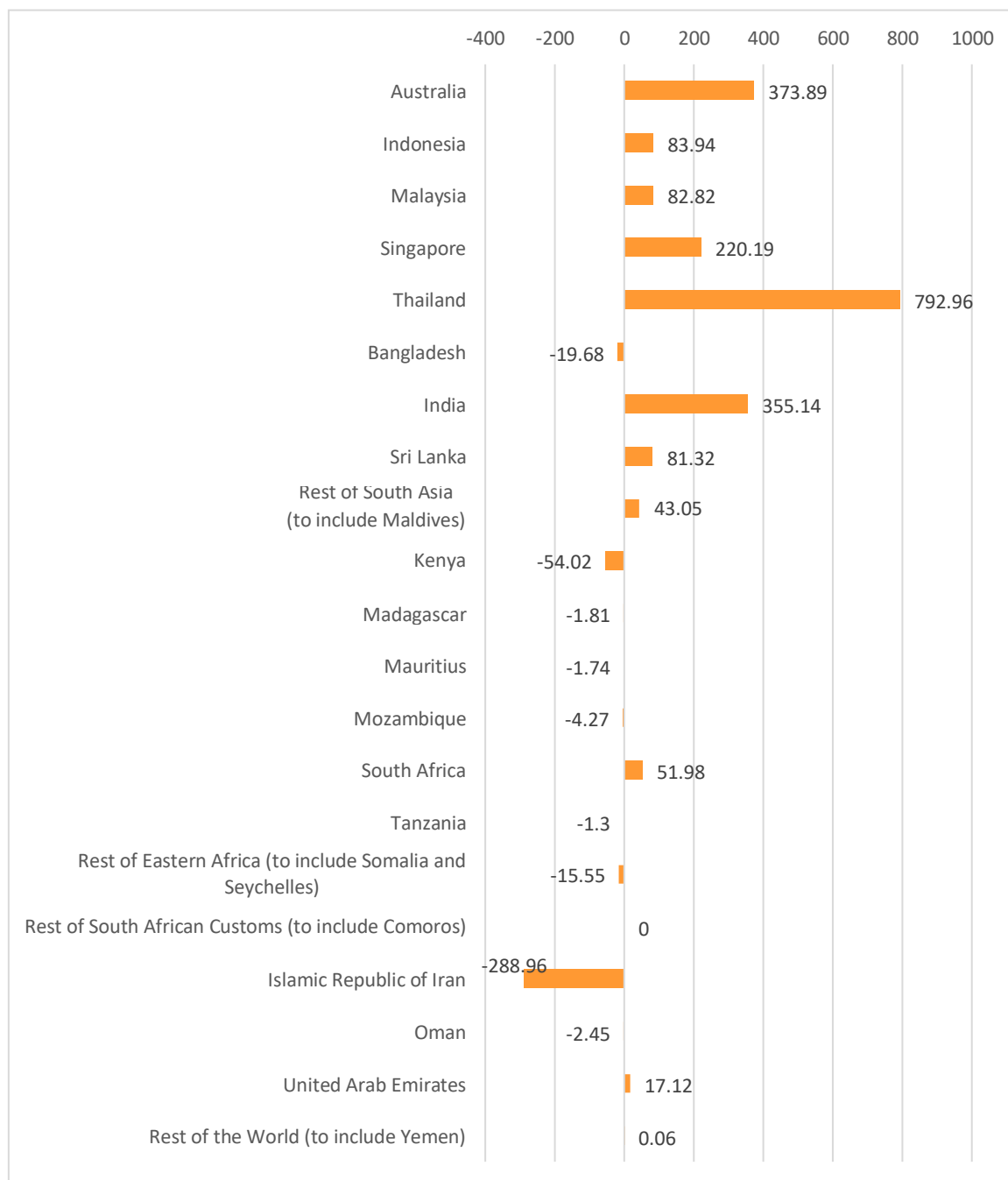
Oman	0.16	0.02	-0.18	0	2.29	0.1	0.02	-0.01	0	0.01	0.05	-0.01	0	-0.01	0	0	0.04	-0.01	-0.01	0
United Arab Emirates	0.12	0.5	0.06	-0.01	2.44	0.25	-0.06	-0.06	-0.08	0.01	0.03	-0.02	-0.02	-0.03	-0.02	-0.02	0.18	-0.04	-0.04	0.01
Rest of the World	0.18	0.08	2.6	-0.12	5.81	0	-0.78	-0.49	-0.51	0.05	-0.14	-0.11	0	0.02	-0.04	-0.04	-0.03	-0.02	0.02	0.15

Figure 3: Change in GDP due to elimination of tariffs (in %)



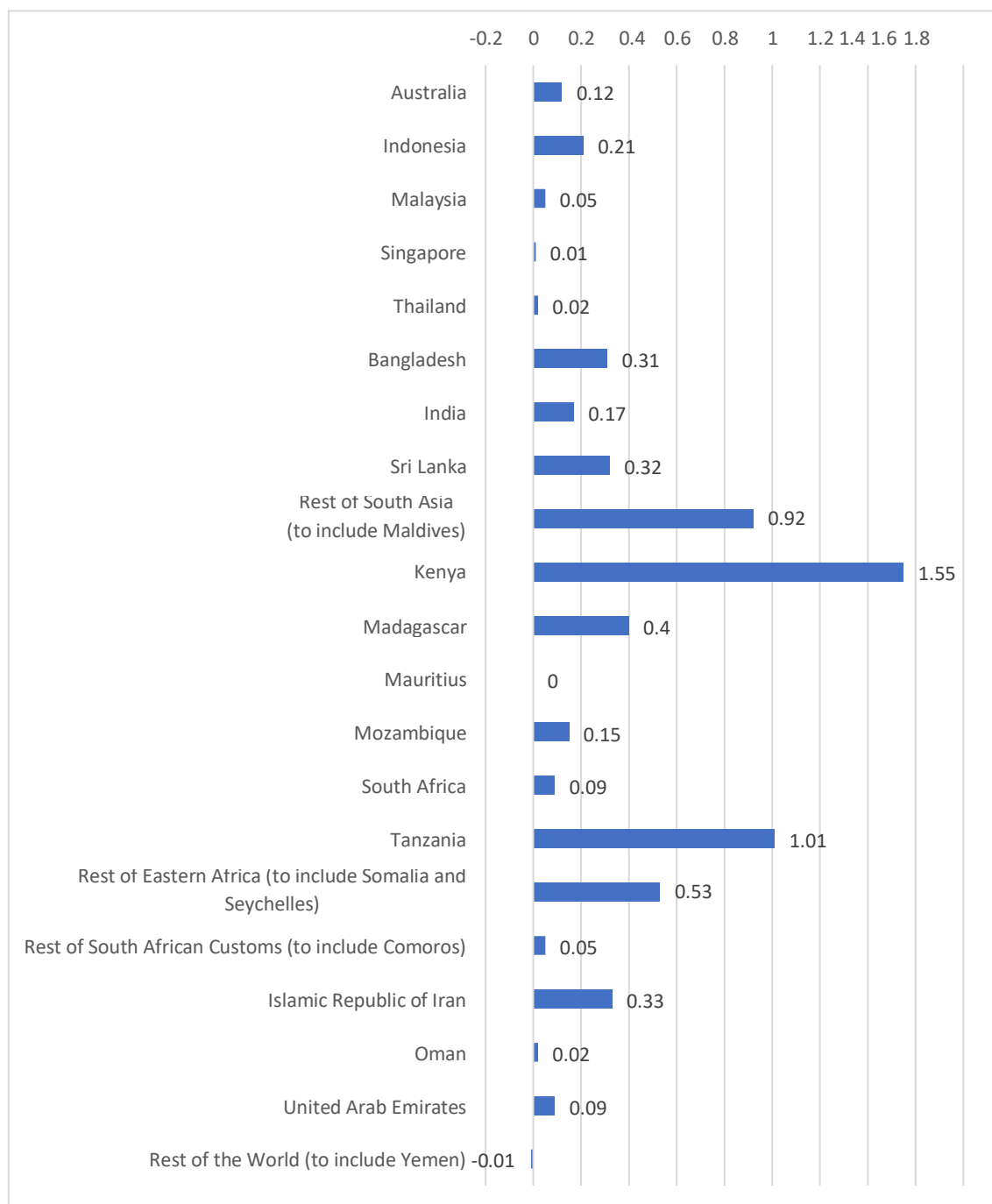
From the Figure 3, we see that the tariff eliminations in the fisheries and sea food products industry leads to a marginal increase in the GDP of most of the IORA member countries.

Figure 4: Change in Equivalent Variations (proxy for Welfare) due to Tariff elimination (in US\$ Million)



There may be an overall increase in the welfare in IORA nations due to tariff eliminations as reflected by its proxy variable, equivalent variations.

Figure 5: Change in Consumer Price Index due to tariff elimination (in %)



The tariff elimination in fisheries and sea food product sector and the resulting expansionary phase may lead to an increase in inflation in IORA nations as depicted in the simulation model given in Figure 5.

Figure 6: Investment in the region (in %)

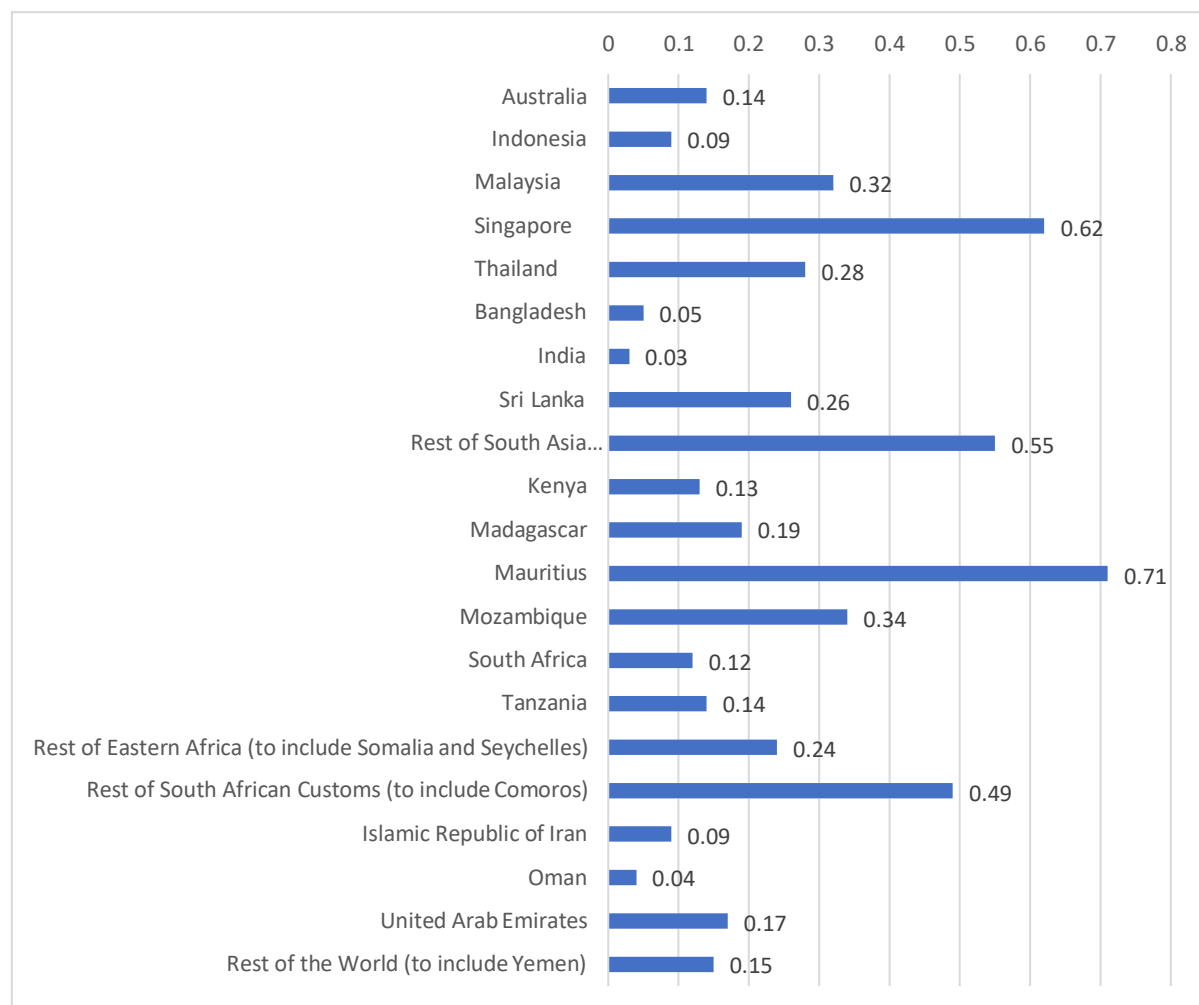


The above figure 6, shows the percent change of Investment proxy of capital investments in the region induced by elimination of tariffs in fisheries and sea food products. The trade liberalization increases profit margins and diversion of factors of production from other sectors to the fisheries and sea food product industry. The economic activity in the economy is stimulated and so capital outflows from other capital-intensive sectors to fisheries and sea food products sector, which has comparatively low capital investment requirements. This is evident in the figure 6, where there is a decline in capital investments in the regions or a very low marginal increase.

SCENARIO II: REDUCTION OF NON-TARIFF BARRIERS

We have simulated the reduction in NTB in fisheries, sea food products, public administration, water transport, tourism, and hospitality industry. NTBs are major concerns for most of the IORA countries. Most of the member countries levy different forms of NTBs. Members belonging to South Asia, trade in different kinds of agricultural products, processed foods, raw materials and manufactured goods. They apply para-tariff, port restrictions, pre-shipment inspections, SPS and TBT restrictions and quality standards. South East Asian countries trade in different kinds of minerals, electrical appliances and machinery is affected by NTBs of import customs surcharge, technical measures, product characteristic requirement, licensing requirement, quality control, and technical regulation on quality and labelling, standard requirement, inspection requirement and tariff rate quota. East African countries levy NTBs by import restriction, procedural delay, non-recognition of SPS certificates and differentiated port procedures. Gulf countries use anti-dumping measures and delay in providing clearances.

Figure 7: Change in GDP due to reduction in Non-tariff barriers (in %)



With a reduction of Non-Tariff Barriers, there may be a rise in trade. There may be more inflow of imports as reflected in the simulated models whose results are portrayed in figure 9. There may be a marginal increase in imports, more than the marginal rise in exports in IORA nations. There may be more competitive cheaper imports which lead to reduction of composite price of intermediaries which may cause excess profits at current prices. This may induce output to expand as reflected in Table 5. This may generate expansionary effects as reflected in figure 10 with increased capital formation mechanisms and increased demand and a rise in CPI reflected in figure 8. Inter sectoral factor flows may take place with mobile endowment shifting to growing sectors leading to increased efficiencies in the economy. There may be a rise in welfare as reflected in Figure 11 and an overall rise in GDP as shown in Figure 7. Australia would gain US\$ 2046.88 Million (0.14%), Singapore with US\$ 1914.56 Million (0.62%), Thailand with US\$ 1114.56 Million (0.28%) and Malaysia by US\$ 1078.25 Million (0.32%).

Figure 8: Change in Consumer Price Index due to reduction in Non-tariff barriers (in %)

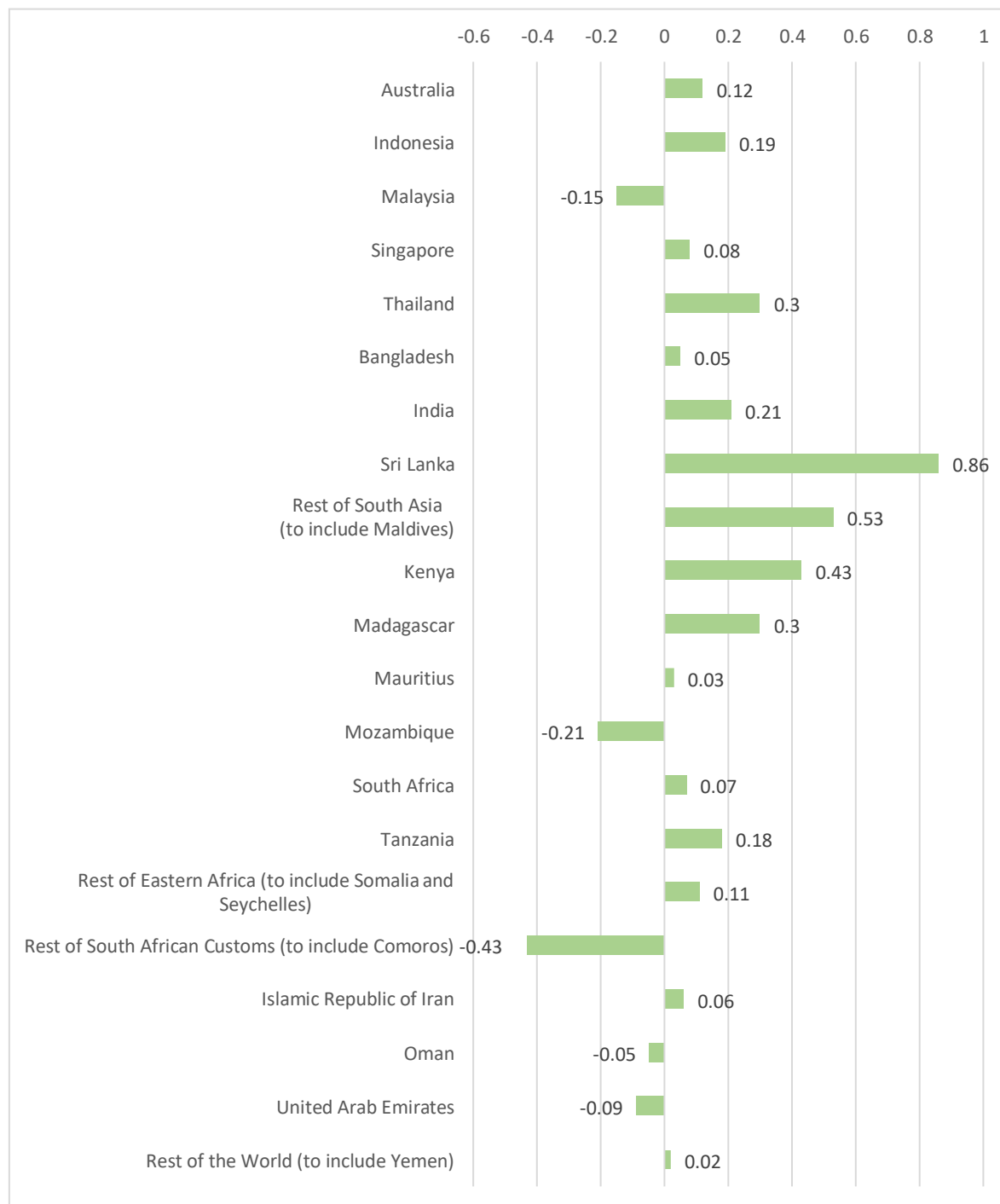
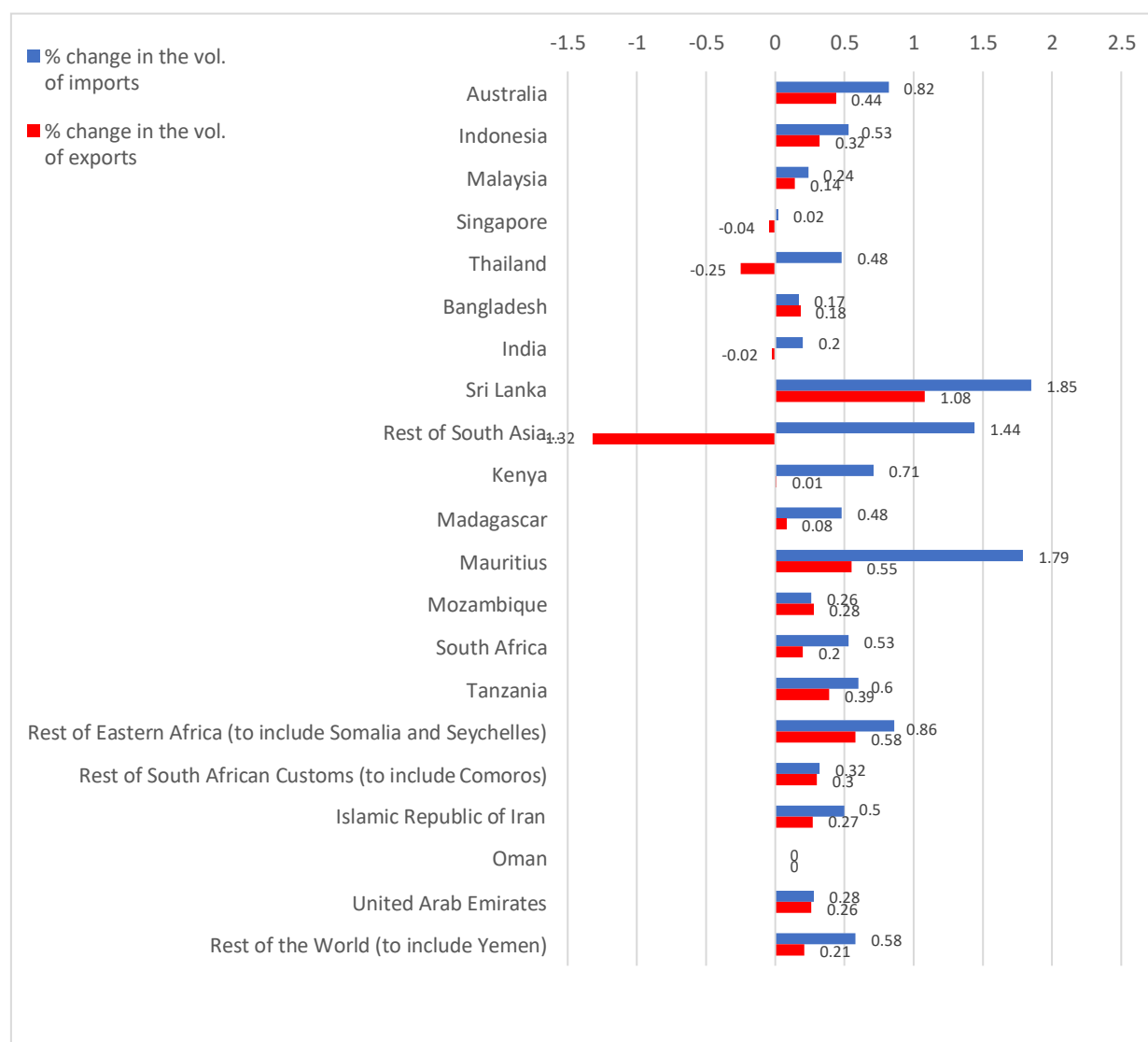
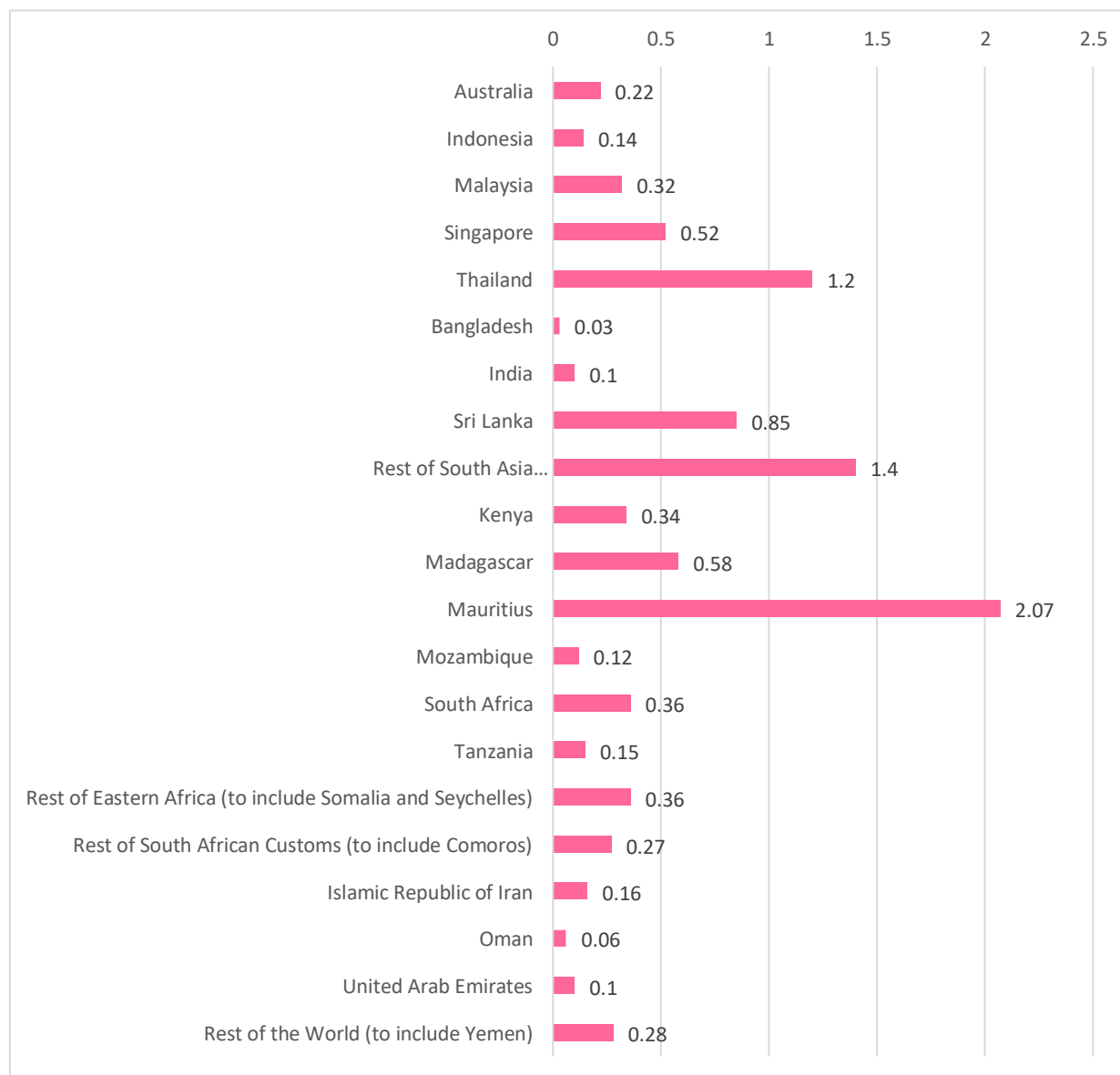


Figure 9: Change in the Volume of Exports and Imports due to reduction in NTBs (in %)

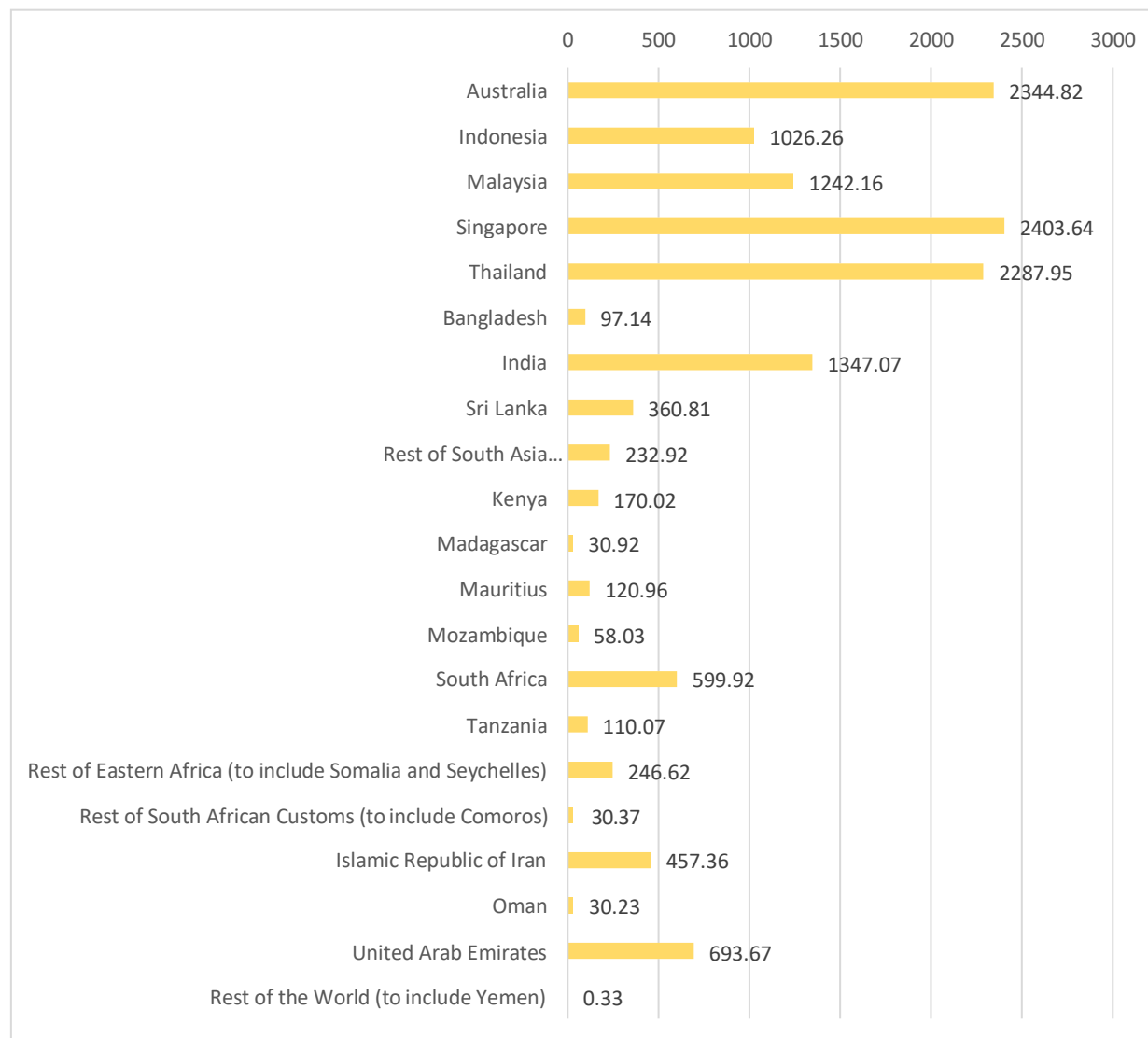


With cheaper imports the profit margins of the producers also increase stimulating demand in other sectors and more employment generation opportunities and rise in production and national output. There has been a rise in industrial output of as shown in Table 5, the fisheries, sea food products, public administration, water transport, tourism and hospitality industry in IORA nations.

Figure 10: Change of Investment due to reduction of Non-tariff barriers (in %)



**Figure 11: Change in Equivalent Variation (proxy for Welfare) due to Non-tariff barriers
(in %)**



There may be a marginal rise in GDP and welfare (equivalent variation is a proxy variable taken for welfare) in IORA countries with NTB reductions.

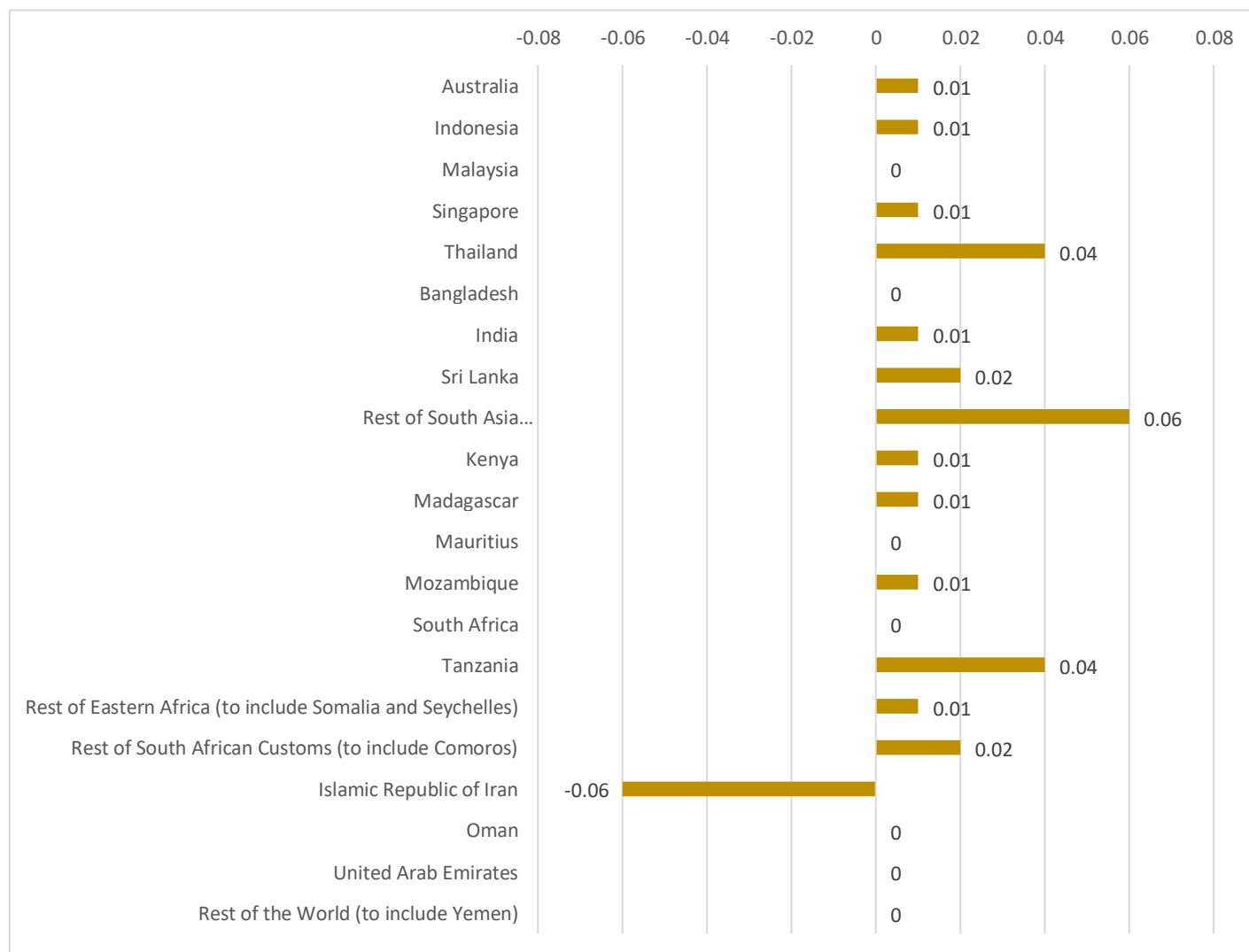
Table 5: Change in Industry's Output in sectors affected by expansion of Blue Economy by reduction in Non-tariff barriers (in %)

Region	Grains Crops	Meat Livestock	Fish	Mineral & Extraction	Food Products	Textiles & Clothing	Light Manufacturing	Heavy Manufacturing	Utilities & Construction	Water Transport	Air Transport	Transport & Communication	Public Administration	Recreation	Other Services	Accommodation	Education	Healthcare	CGDS
Australia	0.02	-0.44	1.06	-0.2	4.98	0.07	0.47	-0.29	0.06	-0.16	0.24	0.03	0.01	0.07	-0.01	0.02	0.05	-0.02	0.12
Indonesia	0.02	0.14	0.18	-0.04	0.52	0.07	-0.06	0.08	0.01	0.03	0.02	0.01	0.01	0.01	0.00	0.02	0.02	0.01	0.02
Malaysia	0.02	0.62	0.52	-0.04	5.28	0.21	0.31	0.13	-0.01	0.00	0.06	0.00	0.02	0.06	0.03	0.02	0.01	0.02	0.04
Singapore	0.09	0.08	0.04	-0.08	18.6	1.52	0.37	-0.27	0.03	0.03	0.02	0.06	0.03	0.02	0.13	0.04	0.03	0.00	0.03
Thailand	0.29	0.58	3.41	-0.3	12.1	0.06	-0.76	0.61	0.34	0.28	0.56	0.06	0.09	0.07	0.18	0.01	0.01	0.09	0.53
Bangladesh	0.00	-0.01	0.17	0.02	1.36	0.03	0.14	0.09	0.04	0.04	0.02	0.01	0.05	0.00	0.00	0.02	0.03	0.02	0.03
India	0.11	-0.04	0.23	-0.04	1.13	0.06	-0.07	0.06	0.01	0.01	0.07	0.00	0.00	0.03	0.04	0.02	0.00	0.01	0.02
Sri Lanka	0.07	0.21	0.48	-0.53	3.6	0.09	1.37	-0.92	0.15	0.56	0.04	0.03	0.03	0.08	0.16	0.13	0.02	0.05	0.26

Rest of South Asia (to include Maldives)	0.1	-0.02	0.87	-0.39	8.77	-0.1	-0.4	0.44	0.59	-0.07	0.26	0.32	0.12	0.05	0.08	0.18	0.07	0.13	0	0.4
Kenya	0.1	0.11	0.07	0.37	0.8	0.02	0.62	0.82	0.74	0	0.29	0.38	0.11	0.11	0.05	0.05	0.08	0.03	0.12	-0.1
Madagascar	0.08	0.08	0.09	0.1	3.06	0.04	0.51	0.14	0.22	-0.01	0.08	0.12	0.03	0.12	0.13	0.06	0.55	-0.1	0.11	0.12
Mauritius	0.03	0.02	0.03	0.02	0.41	0.01	0.1	0.05	0.09	-0.04	0.08	0.01	0.02	0.01	0.03	0.02	0	0	0.01	0.05
Mozambique	0.04	0.03	0.03	0.03	3.15	0	0.13	0.21	0.15	0.06	0.05	0.02	0	0.11	0.04	0.05	0.27	0.07	0.03	0.03
South Africa	0.16	0.01	1.86	-0.05	1.89	0.01	0.11	-0.12	0.19	0.02	0.05	0.08	0	0	0	0	0	0.02	0	0.09
Tanzania	0.14	0.09	0.07	0.3	2.21	0.21	0.76	0.47	0.74	-0.05	0.05	0.09	0.08	0.07	0.27	0.05	0.18	0.03	0.05	0.08
Rest of Eastern Africa	0.01	0.51	0.23	0.12	3.89	0.08	0.27	0.23	0.4	-0.07	0.07	0.18	0	0.06	0.03	0	0.1	0.06	0.06	0.12
Rest of South African Customs	0.05	0.04	0.04	-0.01	0.04	0.01	0.01	0.01	0	-0.03	0.01	0.01	0	0.02	0.01	0.01	0.03	0.02	0.01	0.02
Islamic Republic of Iran	0.02	0.01	0.05	0.05	0.43	0	0.09	0.08	0.04	-0.01	0.1	0.07	0.01	0.06	0.01	0.01	0.06	0.03	0.06	0.05

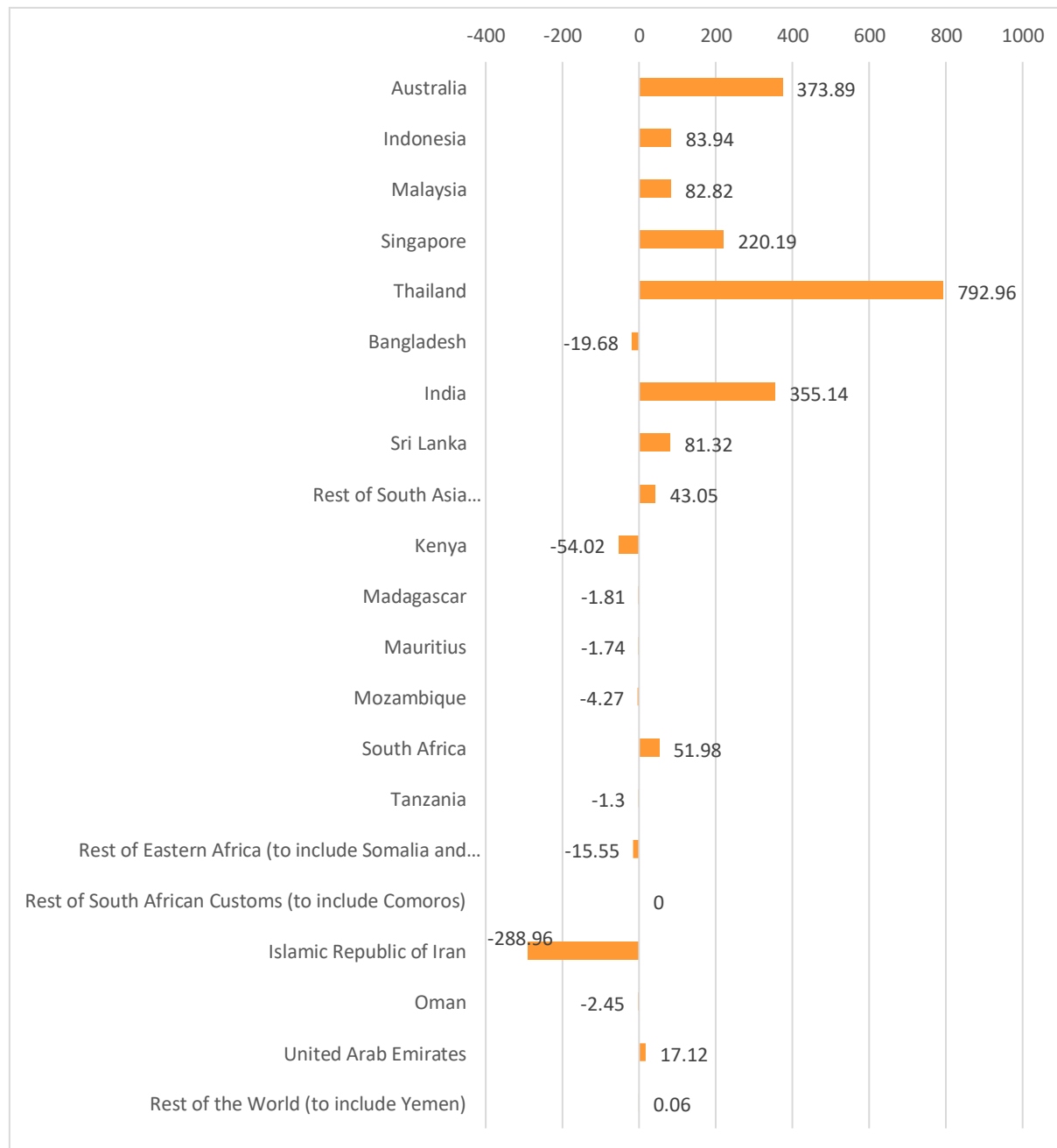
Oman	0.1 6	0.0 2	- 0. 18	0	2. 29	0.1 0.1	0.0 2	- 0.01	0	0.01	0.0 5	- 0.0 1	0	- 0.0 1	0	0	0.0 4	- 0.0 1	- 0.0 1	0
United Arab Emirates	0.1 2	0.0 0.5	0. 06	-0.01	2. 44	0.2 5	0.0 6	- 0.06	- 0.0 8	0.01	0.0 3	0.0 2	0.0 2	0.0 3	0.0 2	0.0 2	0.1 8	0.0 4	0.0 4	0.0 1
Rest of the World	0.1 8	0.0 8	2. 6	-0.12	5. 81	0	0.7 8	- 0.49	- 0.5 1	0.05	0.1 4	0.1 1	0	0.0 2	0.0 4	0.0 4	0.0 3	0.0 2	0.0 2	0.1 5

Figure 3: Change in GDP due to elimination of tariffs (in %)



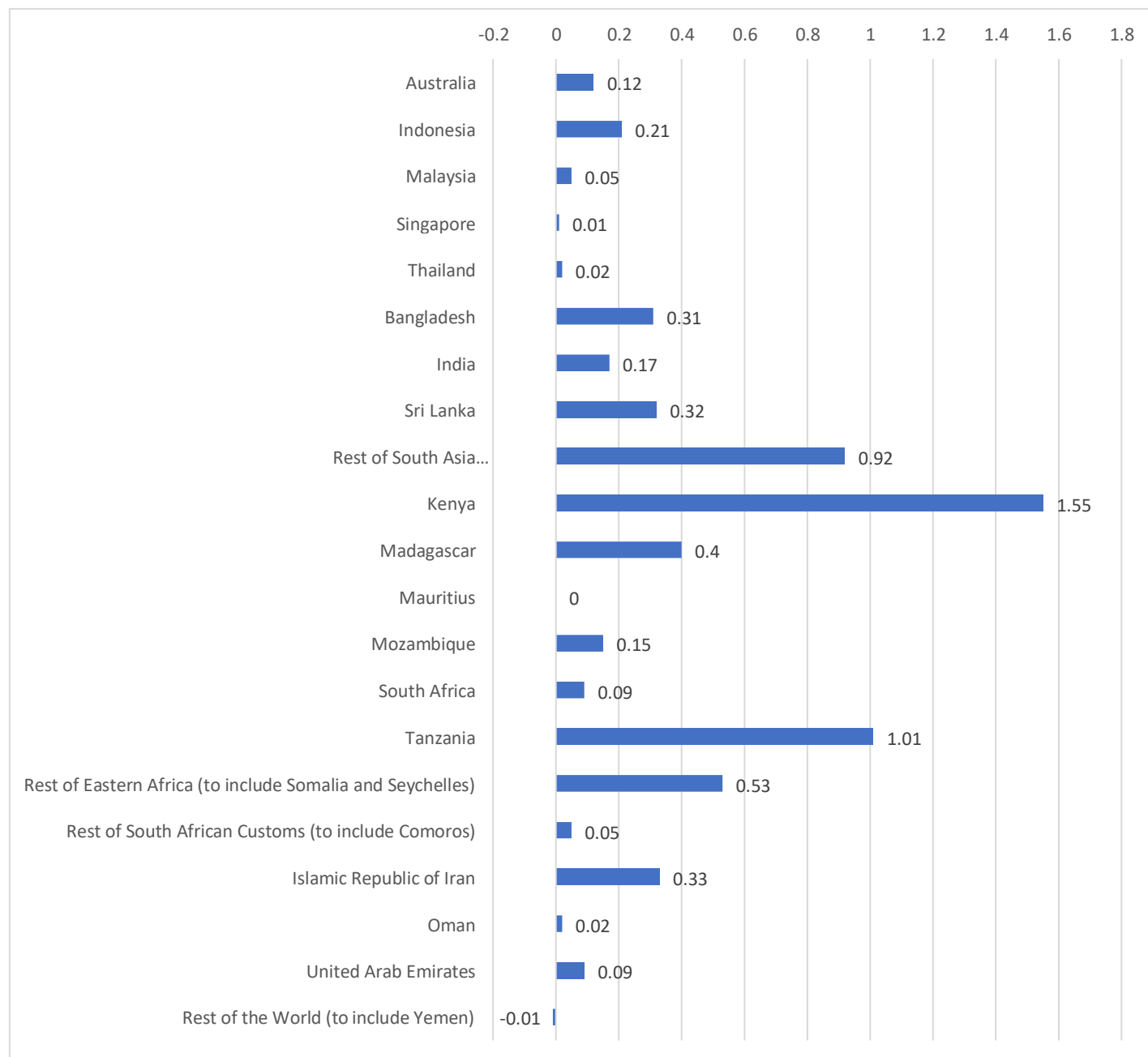
From the Figure 3, we see that the tariff eliminations in the fisheries and sea food products industry leads to a marginal increase in the GDP of most of the IORA member countries.

Figure 4: Change in Equivalent Variations (proxy for Welfare) due to Tariff elimination (in US\$ Million)



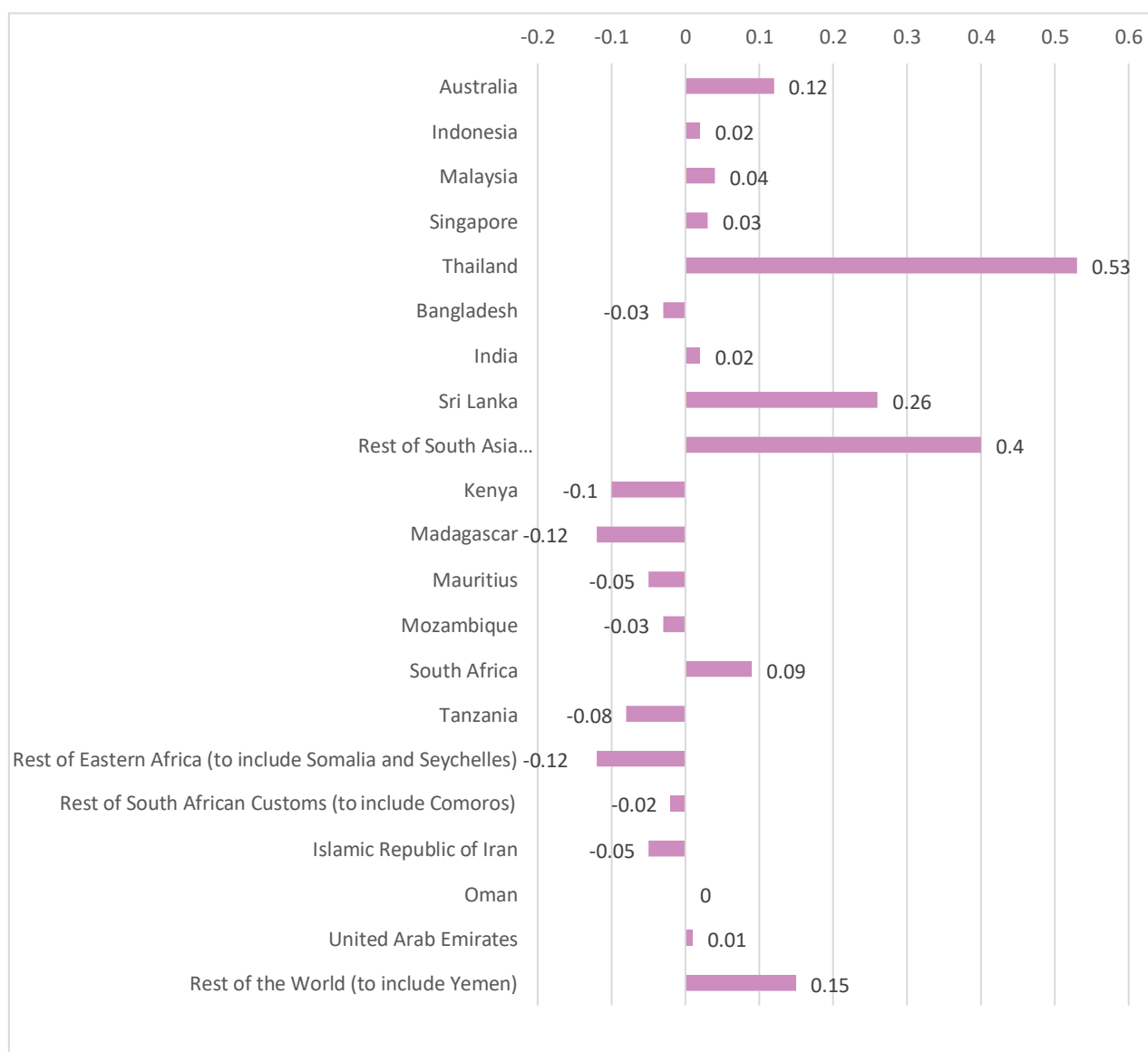
There may be an overall increase in the welfare in IORA nations due to tariff eliminations as reflected by its proxy variable, equivalent variations.

Figure 5: Change in Consumer Price Index due to tariff elimination (in %)



The tariff elimination in fisheries and sea food product sector and the resulting expansionary phase may lead to an increase in inflation in IORA nations as depicted in the simulation model given in Figure 5.

Figure 6: Investment in the region (in %)

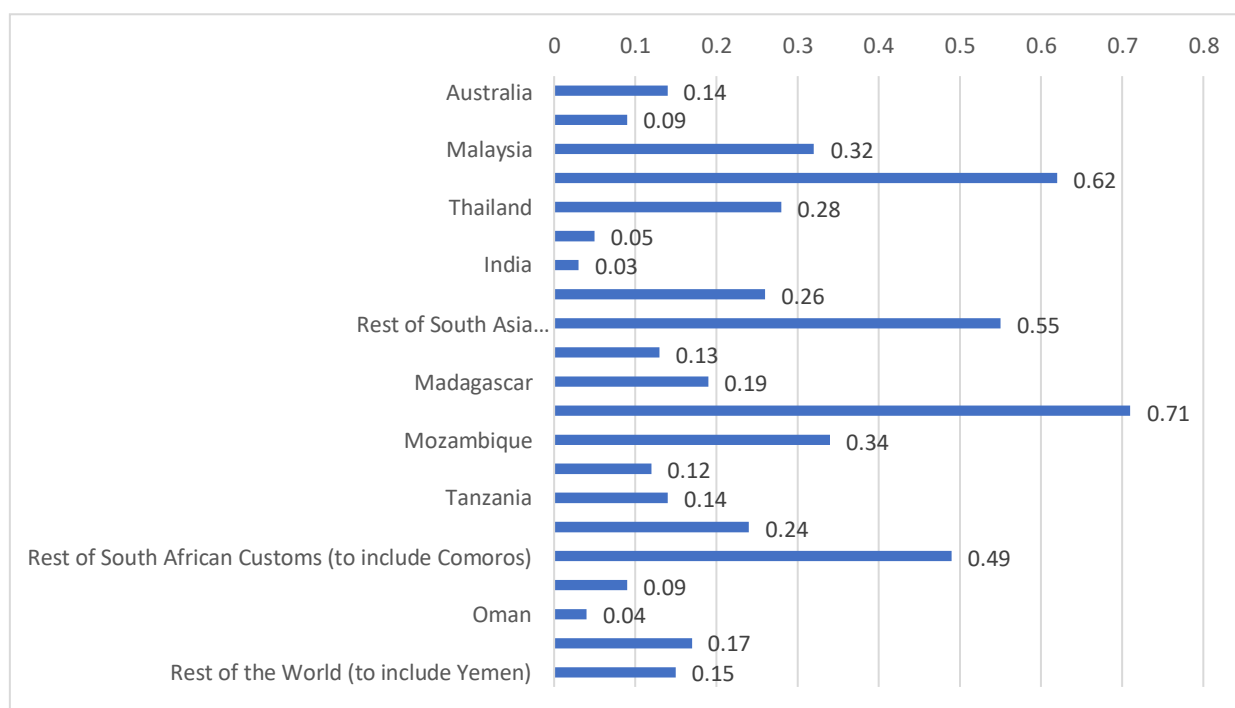


The above figure 6, shows the percent change of Investment proxy of capital investments in the region induced by elimination of tariffs in fisheries and sea food products. The trade liberalization increases profit margins and diversion of factors of production from other sectors to the fisheries and sea food product industry. The economic activity in the economy is stimulated and so capital outflows from other capital intensive sectors to fisheries and sea food products sector, which has comparatively low capital investment requirements. This is evident in the figure 6, where there is a decline in capital investments in the regions or a very low marginal increase.

SCENARIO II: REDUCTION OF NON-TARIFF BARRIERS

We have simulated the reduction in NTB in fisheries, sea food products, public administration, water transport, tourism, and hospitality industry. NTBs are major concerns for most of the IORA countries. Most of the member countries levy different forms of NTBs. Members belonging to South Asia, trade in different kinds of agricultural products, processed foods, raw materials and manufactured goods. They apply para-tariff, port restrictions, pre-shipment inspections, SPS and TBT restrictions and quality standards. South East Asian countries trade in different kinds of minerals, electrical appliances and machinery is affected by NTBs of import customs surcharge, technical measures, product characteristic requirement, licensing requirement, quality control, and technical regulation on quality and labelling, standard requirement, inspection requirement and tariff rate quota. East African countries levy NTBs by import restriction, procedural delay, non-recognition of SPS certificates and differentiated port procedures. Gulf countries use anti-dumping measures and delay in providing clearances.

Figure 7: Change in GDP due to reduction in Non-tariff barriers (in %)



With a reduction of Non-Tariff Barriers, there may be a rise in trade. There may be more inflow of imports as reflected in the simulated models whose results are portrayed in figure 9. There may be a marginal increase in imports, more than the marginal rise in exports in IORA nations. There may be more competitive cheaper imports which lead to reduction of composite price of intermediaries which may cause excess profits at current prices. This may induce output to expand as reflected in Table 5. This may generate expansionary effects as reflected in figure 10 with increased capital formation mechanisms and increased demand and a rise in CPI reflected in figure 8. Inter sectoral factor flows may take place with mobile endowment shifting to growing sectors leading to increased efficiencies in the economy. There may be a rise in welfare as reflected in Figure 11 and an overall rise in GDP as shown in Figure 7. Australia would gain US\$ 2046.88 Million

Figure 8: Change in Consumer Price Index due to reduction in Non-tariff barriers (in %)

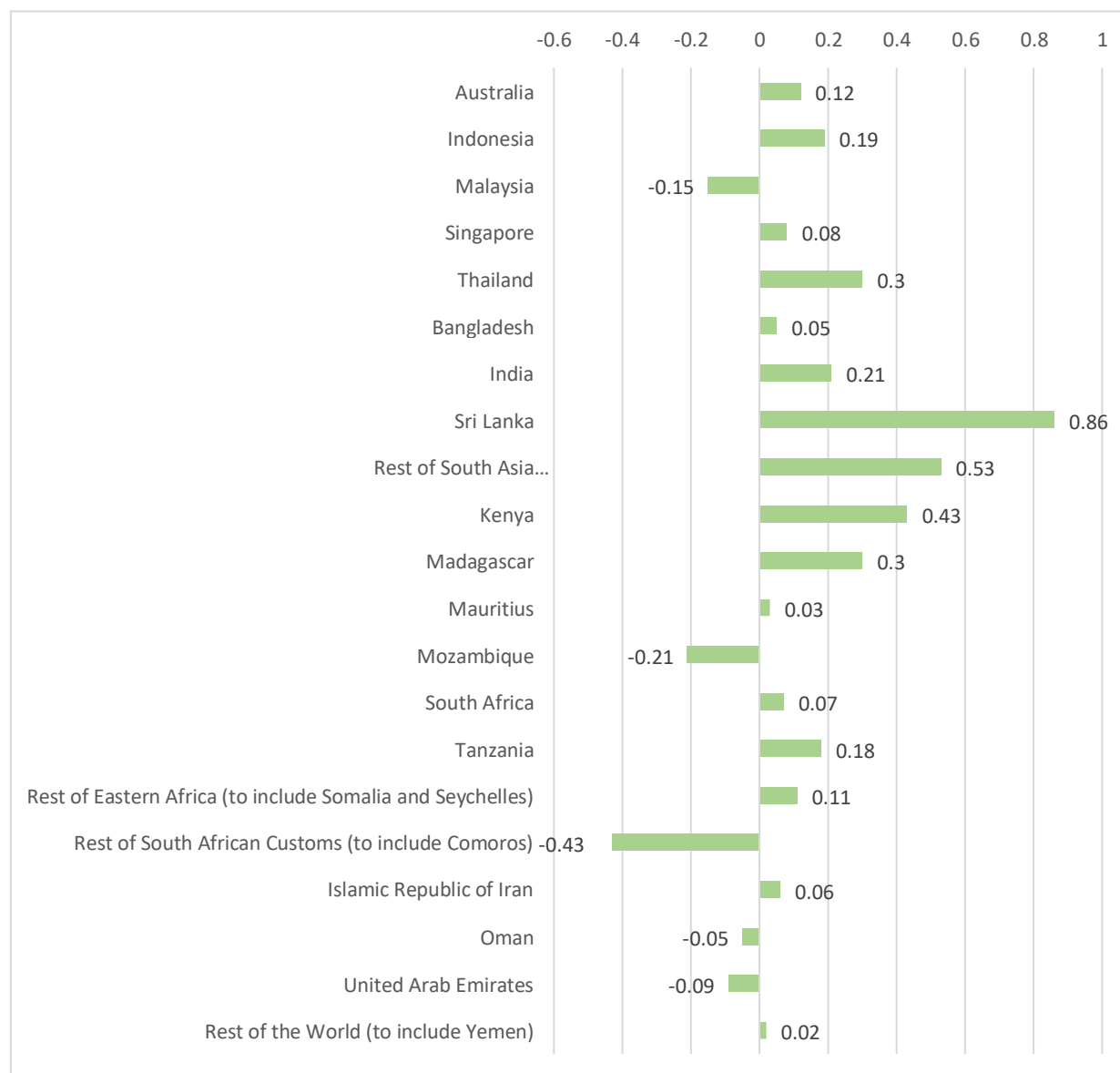
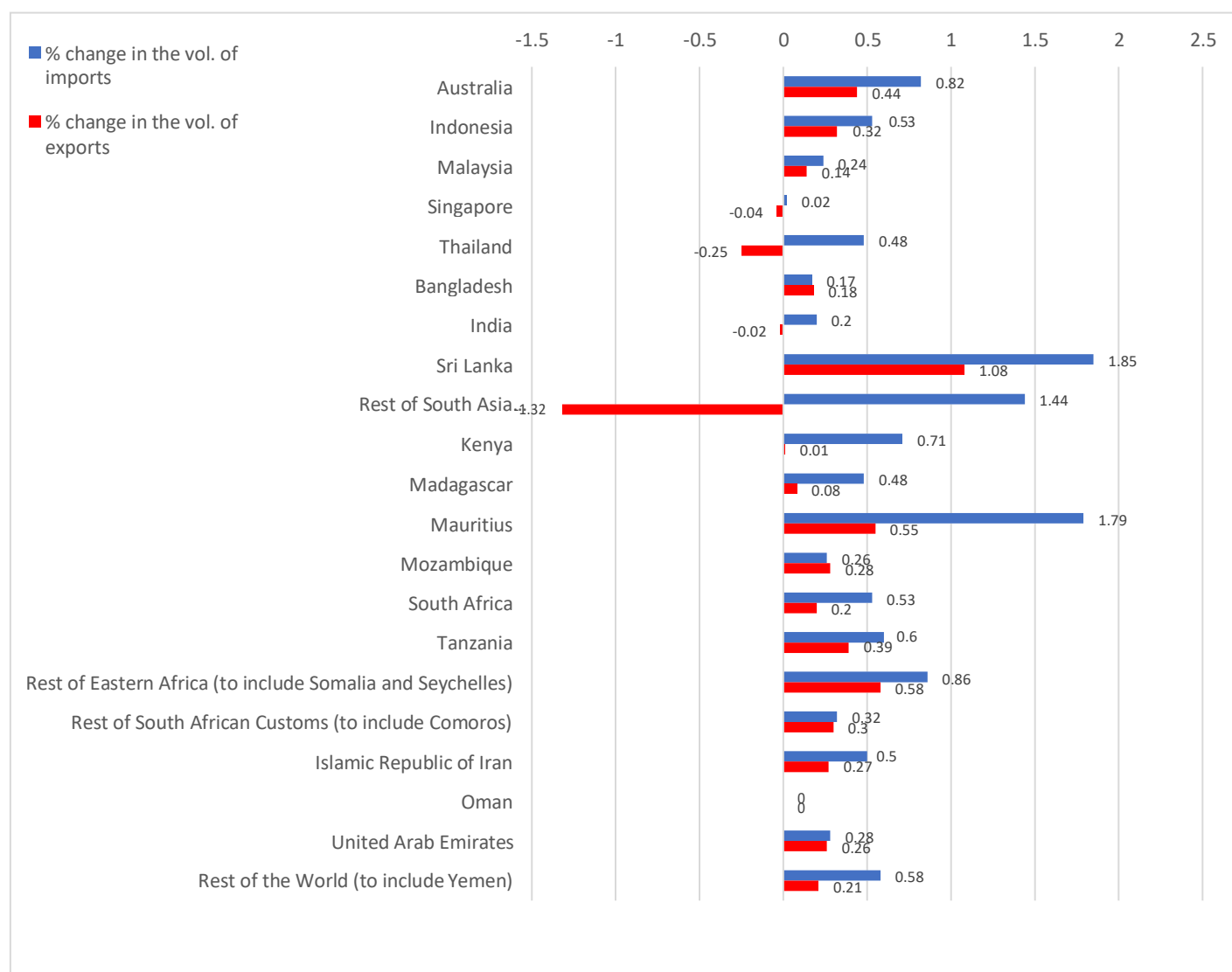


Figure 9: Change in the Volume of Exports and Imports due to reduction in NTBs (in %)

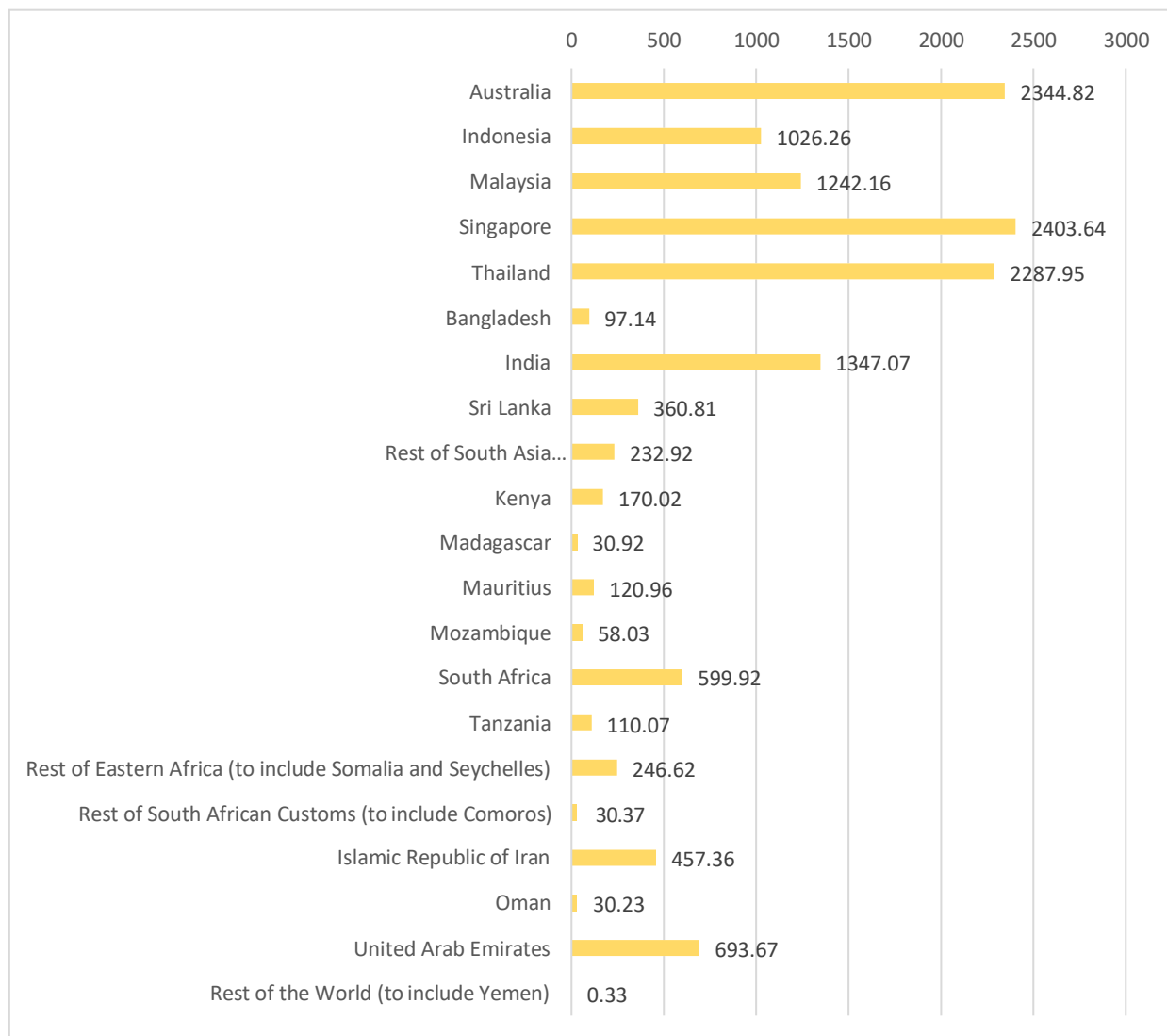


With cheaper imports the profit margins of the producers also increase stimulating demand in other sectors and more employment generation opportunities and rise in production and national output. There has been a rise in industrial output of as shown in Table 5, the fisheries, sea food products, public administration, water transport, tourism and hospitality industry in IORA nations.

Figure 10: Change of Investment due to reduction of Non-tariff barriers (in %)



**Figure 11: Change in Equivalent Variation (proxy for Welfare) due to Non-tariff barriers
(in %)**



There may be a marginal rise in GDP and welfare (equivalent variation is a proxy variable taken for welfare) in IORA countries with NTB reductions.

Table 5: Change in Industry's Output in sectors affected by expansion of Blue Economy by reduction in Non-tariff barriers (in %)

Region	Grains and Crops	Meat and Livestock	Fish	Mining and Extraction	Food Products	Process Food	Textiles and Clothing	Light Manufacturing	Heavy Manufacturing	Utilities and Construction	Water Transport	Air Transport	Transport and Communications	Public Administration	Recreation	Other Services	Accommodation and Food	Education	Healthcare	CGDS
Australia	-0.23	-0.55	0.52	-0.21	-0.46	-0.01	-0.58	-0.41	-0.58	0.13	1.93	-0.09	0	0.22	0.8	0.01	0.59	-0.04	0.04	0.22
Indonesia	0.01	0.19	0.51	-0.2	1.99	-0.37	-0.76	-0.37	-0.44	0.11	0.46	0.04	0.05	0.2	0.34	0.05	0.07	-0.03	0.04	0.14
Malaysia	-0.01	1.12	0.45	-0.21	4.41	-0.03	-0.637	-0.37	-0.8	0.09	2.65	0.06	0.02	0.38	4.82	0.07	1.73	0.07	0.18	0.32
Singapore	-0.46	1.1	1	-0.53	14.9	1.94	-2.04	-2.27	-1.29	0.29	4.08	0.19	-0.2	0.86	3.5	0.63	6.3	-0.17	0.3	0.52
Thailand	0.16	-0.51	3.55	-0.65	11.6	-0.02	-2.02	-1.56	-1.21	0.67	8.35	-1.18	-0.2	0.44	3.32	-0.38	1.72	-0.06	0.2	1.2
Bangladesh	0.06	0.02	0.09	0	1.68	-0.05	-0.37	-0.07	-0.04	-0.02	0.08	-0.01	0.02	-0.21	-0.13	0.03	0.03	0.06	0.05	0.03

India	0.28	-0.14	0.3	-0.15	2.98	0.14	0.41	-0.0	0.0	0.05	2.23	-0.29	0.02	0.08	1.25	-0.17	0.2	0.02	0.03	0.1
Sri Lanka	-0.25	0.37	0.59	-1.55	2.96	0.39	-0.4	-0.51	-0.03	0.58	15.85	0.27	0.1	0.16	0.82	-0.24	0.51	-0.02	0.24	0.85
Rest of South Asia (to include Maldives)	-0.21	0.28	1.03	-1.29	2.08	0.2	0.69	-0.14	1.155	-0.16	1.32	0.82	0.18	0.55	2.77	-0.21	1.53	-0.25	0.53	1.4
Kenya	-0.14	0.13	0.19	-0.76	0.18	0.08	0.71	-0.88	-0.1	0.17	7.55	0.66	0.11	0.7	-0.23	0.06	0.25	0.2	0.36	0.34
Madagascar	-0.17	0.48	0.68	-0.47	7.17	0.45	2.03	-0.55	0.08	0.13	1.32	0.42	0	0.09	-3.23	-0.1	8.47	0.02	0.15	0.58
Mauritius	0.28	-0.53	0.38	-0.89	9.42	2.01	4.49	-1.62	1.137	1.5	9.39	0.88	0.34	1.12	2.36	0.55	5.65	0.13	0.36	2.07
Mozambique	0.21	0.2	0.29	-0.05	-1	0.26	0.27	-0.23	0.056	-0.1	7.53	0.29	0.07	0.03	-1.85	0.16	0.76	0.1	0.32	0.12
South Africa	-0.01	0.07	1.05	-0.15	1.64	0.01	0.26	-0.39	0.063	0.13	0.36	0.21	-0.12	0.23	1.44	0.06	0.09	-0.02	0.06	0.36

Tanzania	0.09	0.09	0.86	-0.59	1.35	0.21	-1.46	-0.94	-1.43	0.1	0.48	0.07	-0.11	0.07	4.76	0.08	2.06	-0.03	0.01	0.15
Rest of Eastern Africa (to include Somalia and Seychelles)	-0.46	0.27	0.07	-0.27	1.27	0.01	-0.38	-0.48	-0.72	0.26	1.61	0.08	0.07	0.73	0.68	0.11	0.6	-0.05	0.23	0.36
Rest of South African Customs (to include Comoros)	0.06	0.45	0.09	-0.14	0.47	0.06	-0.24	-0.16	-0.17	0.17	1.76	0.15	-0.01	-0.04	-0.61	0.14	1.48	0.12	0.22	0.27
Islamic Republic	-0.02	0.03	0.09	-0.1	0.24	0.03	-0.23	-0.11	-0.01	0.04	1.67	0.2	0.01	0.19	0	-0.06	0.49	-0.03	0.05	0.16

of Iran																				
Oma n	0.63	0.7	- 0. 58	- 0.01	0.6 3	0. 47	0.0 9	- 0. 01	0. 05	0.05	- 0.73	- 0.13	0.0 2	0.0 2	-0.12	- 0.0 1	0.1 3	- 0.01	0	0.0 6
Unite d Arab Emir ates	0.23	1.51	- 0. 72	- 0.07	0. 3	0. 75	0.2 4	- 0. 25	- 0. 37	0.09	2.69	1.52	0.0 7	0.3 9	0.11	- 0.0 1	1.0 1	- 0.06	-0.02	0.1
Rest of the Worl d (to inclu de Yeme n)	-0.21	0.04	0. 97	- 0.17	2.4 3	0. 09	1.1 1	- 0. 79	- 0. 75	0.1	2.33	0.09	0.0 1	0.1 7	1.04	- 0.0 3	0.7	- 0.01	0.08	0.2 8

CONCLUSION

Indian Ocean Rim is a key strategic area with huge potential for growth, which joins a number of developed and emerging economies. For the realization of the objectives of the Blue Economy for a smart, sustainable and inclusive growth of the Indian Ocean Region, it is important to bring out trade liberalization in the region with its trading partners.

Using the Computational General Equilibrium Model, we have simulated the effects of elimination of tariffs and non-tariff barriers in the blue economy sectors on key macroeconomic variables. The results show a rise in GDP and overall welfare and much greater increase in trade. Some countries witness increase in trade to the tune of 1% or higher, while others have smaller changes. The positive impact on GDP and welfare gains of non-tariff barriers' reduction is much greater than that of tariff eliminations. Similarly, there is much more investment gains in the IORA member countries due to NTB's than the tariff eliminations. There have been gains in industrial output of industries like water transport, defense, fisheries, health care, utilities like gas manufacture and its distribution, and construction. Thus, on the policy front the paper brings out that the economic and welfare gains due to reductions in Non-Tariff barriers are more than the tariff elimination policies, for the sustainable growth of the Blue Economy.

There are, however, some caveats and limitations of our study. We assume full employment in our model, which reduces the magnitude of impact, because the employment gains in the blue economy sectors are offset by losses in employment in other sectors. Therefore, our estimates are conservative in nature, and the real impact may be higher than what we predict. Furthermore, countries like Iran appear to lose in the trade liberalization scenario, because of profound impact of the declining sectors on the economy. This loss might also be mitigated in real world by an overall expansion in employment. Furthermore, our paper does not capture dynamics and capital accumulation, which can have even greater impact. In other words, our paper is a first attempt in this direction, and can provide sufficient evidence that the blue economy trade policies can have a profound economic impact even in such a conservative setting.

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Report on The Initiatives on Blue Economy by the Federation of Indian Chambers of Commerce and Industry (FICCI)

As the Business Secretariat of IORA in India, FICCI is pleased to share the key takeaways of the research being conducted on Blue Economy since 2016 with the constitution of the FICCI Blue Economy Thought Leadership Initiative. In this endeavor that has resulted in two published studies (2017 and 2020), FICCI has received invaluable guidance from CIOS and inspiration and encouragement from Secretary General, IORA. Through this publication we hope to reach out to our friends in IORA Member States and Dialogue Partners to broaden our work and integrate with the Indian Ocean region for shared prosperity and growth through Blue Economy. Such partnership assumes great urgency and relevance in the current challenging times and the post pandemic period.

The feature is submitted by the Federation of Indian Chambers of Commerce and Industry (FICCI). FICCI serves as the Business Secretariat of Indian Ocean Rim Association (IORA) in India and has been actively pursuing Government of India's priority agenda with IOR through a range of policy dialogues, workshops, capacity building programmes and industry led initiatives.

The Federation of Indian Chambers of Commerce and Industry (FICCI) is India's apex industry association, founded on the call of the Father of the Nation Mahatma Gandhi in 1927. The Multilateral Engagement Division of FICCI works to strengthen economic relations and build new connects by leveraging the synergy of regional and multilateral groupings. Besides IORA, FICCI holds the Business Secretariat for BRICS, Shanghai Cooperation Organisation (SCO), ASEAN India Business Council (AIBC) and is a founding member for SAARC Chamber of Commerce and Industry, Boao Forum and CACCI. In addition, FICCI spearheads several initiatives at bilateral and multilateral levels across the world. The FICCI thought leadership project on Blue Economy was instituted in 2016. The project engages with stakeholders in India and abroad to develop Blue Economy linkages and partnerships for mutually beneficial growth while advocating for eco-friendly, sustainable and inclusive development.

Blue Economy: Opportunity without Borders

Blue Economy is a progressive paradigm in the development discourse which gives equal weightage to economic growth and environmental sustainability.

Blue Economy encompasses a wide range of economic activities pertaining to sustainable development of resources and assets in the oceans, related rivers, water bodies and coastal regions – in a manner that ensures equity, inclusion, innovation and modern technology³⁸.

‘Blue Economy advocacy’ is an imperative for IORA countries as there remains immense potential for the development of resources – including food, livelihoods, tourism, minerals resources, bioprospecting, the mining of seabed resources and ‘blue energy’.

Blue Economy – the charted path

With two-thirds of the earth being ‘blue’ it is inevitable that we explore the facets of the Blue world and its impact on development and economic opportunities.



Oceans cover 72 percent of earth providing food security, livelihood and communication highway accounting for over 90 percent of global trade. Marine and coastal environments also play a major role in maintaining ecological balance and offer valuable healing elements.

India requires focused strategy required to address the impact of COVID-19 outbreak on Blue Economy Sectors

Blue Economy encompasses a wide range of economic activities pertaining to sustainable development of resources and assets in the oceans, related rivers, water bodies and coastal regions – in a manner that ensures equity, inclusion, innovation and modern technology.

³⁸ As defined by the FICCI Taskforce on Blue Economy

Facts and opinions published in the Journal of Indian Ocean Rim Studies (JIORS) express solely the opinions of the respective authors. This in no way represents the views of IORA. The Authors are responsible for their citing of sources and the accuracy of their references and bibliographies. The editors cannot be held responsible for any lacks or possible violations of third parties' right.

The paradigm of Blue Economy, which is a multi-dimensional concept, has a direct bearing on the contemporary discourse concerning geo-economics and the imperative to increase productivity of oceanic and other water resources, attainment of Sustainable Development Goals, and the challenge of ensuring maritime security against traditional and non-traditional threats.

Hence the opportunity presented by Blue Economy has opened up a new horizon for economic development of countries through the use of ocean and marine resources, both at the national and international level, with considerable gains in the collective quest by IORA Member States for socio-economic equity, inclusive development and building partnerships and strengthening synergy through interlinkages provided by oceans.

Scope

In popular perception, the ocean/marine economy has been equated with the fishing sector, but the coverage of Blue Economy is well beyond fisheries. It encompasses the entire economy of a littoral country, covering all economic activities including agriculture, mining, construction, manufacturing and services sector.

Development of Blue Economy depends on the evolution of the established and emerging sectors and ocean-based industries and activities. Broadly, established ocean activities include fisheries, shipping, port and maritime logistics, marine coastal tourism and leisure, conventional minerals exploration and production, and marine construction activities.

Emerging sectors encompass renewable ocean energy including offshore wind, tidal and wave energy; offshore extraction of oil and gas in deep-sea and other extreme locations; seabed mining for metals and minerals; marine aquaculture; marine biotechnology; ocean monitoring, control and surveillance and education and research. Emerging sectors are characterized by the use of cutting-edge science and technology in their operations.

It is in this context, that FICCI, India's National Industry Association (www.ficci.com) initiated a thought leadership project on Blue Economy. The first step was the establishment of an eminent Taskforce on Blue Economy Chaired by Amb. Rajiv Bhatia (an erstwhile Indian diplomat with rich experience of serving in several important capacities including as Head of Mission in key IORA Member States).

It was important to seek the views and close involvement of IORA in this endeavour:

First, FICCI serves as the Business Secretariat of IORA in India. Secondly, Blue Economy is a cross cutting priority area in IORA and Thirdly, the geo economic significance of the Indian Ocean: Accounting for more than 80 percent of global trade, marine and coastal environments constitute a key resource for economic development.

With nearly half the world's population projected to be residing in the Indian Ocean Rim (IOR) countries by 2050, the region is making a geopolitical shift from its identity as the 'Ocean of the South' to the 'Ocean of the Centre', and further to the 'Ocean of the Future' as its core position in terms of global trade, industry, labour, environment and security is likely to shape the 21 -century world. Accordingly, IORA places great emphasis on developing Blue Economy as a cross cutting priority area.

Given this fact, FICCI engaged actively with IORA Secretariat at highest levels, inviting the opinion of the Secretary General who nominated Prof V N Attri, CIOS to the Taskforce.

The Taskforce released a Knowledge Report in 2017 titled “Blue Economy Vision 2025 - Harnessing Business Potential for India Inc and International Partners”. In addition to national and international platforms, it was released at the IORA Ministerial Conference on Blue Economy in Jakarta in 2017.

The study highlighted the need for a balanced approach, combining imperatives for growth and sustainability the value of Public-Private Partnership and deploying technology for optimal development of Blue Economic opportunities for India Inc. and its international partners. The study also calls for deploying technology for optimal development of Blue Economic opportunities for India Inc. and its international partners. For this study, FICCI conducted stakeholder consultations in 3 coastal states-West Bengal, Maharashtra and Tamil Nadu.

The Indian Perspective on Blue Economy

India’s engagement with the Blue Economy has been one of **PM Modi’s foremost foreign policy priorities**.

To promote this connect, the Honourable Prime Minister has visited three Indian Ocean Rim (IOR) countries namely, *Seychelles, Mauritius* and Sri Lanka in 2015 and recently countries of East and South Africa – where he has called for building closer economic ties between India and IORA Member States.

India has a long coastline of 7,500 km (including island territories) which provides immense opportunities for Blue Economy. India’s engagement with the Blue Economy has been a foremost policy priority. India endorses the growth of the Blue Economy in a sustainable, inclusive and people centred manner. The growing importance accorded to the Blue Economy was clear when the Indian government’s vision was articulated during Prime Minister Narendra Modi’s visit to Mauritius and Seychelles in March 2015. PM Modi’s vision for the seas through “**Security and Growth for All in the Region**” (**SAGAR**) endorsed **Blue Economy as a new pillar of economic activity in the coastal areas and linked hinterlands through sustainable tapping of oceanic resources**.

“To me the Blue Chakra or wheel in India’s national flag represents the potential of Blue Revolution or the Ocean Economy. That is how central the ocean economy is to us”.

-PM Narendra Modi

FICCI is committed in the task of implementing Government of India’s policy in the Indian Ocean coastal, island territories and exclusive economy zone (EEZ).

Blue Economy: Strengthening the Regional Synergy, and Forming Sub Regional Connect between IORA Member States

Blue Economy as the special focus area for IORA was recognised at the 14th IORA Ministerial Meeting in Perth, Australia, in 2014. The establishment of the Working Group of Blue Economy emanated from the IORA Action Plan 2017-2021 that was adopted at the Leaders’ Summit that was held on 5-7 March 2017 in Jakarta, Indonesia. The meeting also saw the adoption of the Jakarta Concord that reiterate IORA’s commitment to promote Blue Economy development in the region as a key source of inclusive economic growth, job creation and education, based on the evidence-based sustainable management of marine resources.

Considering its wide range of valuable resources, the Blue Economy has been gaining increasing interest in IORA Member States that are all committed to the establishment of a common vision that would make this sector a driver for balanced economic development in the Indian Ocean Rim region.

It is envisaged that Blue Economy development in IORA will further be strengthened through the focused plan of the Blue Economy Working Group (WGBE).

Strengthening Blue Economy Agenda in IORA

With nearly half the world's population projected to be residing in the Indian Ocean Rim (IOR) countries by 2050, the region is making a geopolitical shift from its identity as the 'Ocean of the South' to the 'Ocean of the Centre', and further to the 'Ocean of the Future' as its core position in terms of global trade, industry, labour, environment and security is likely to shape the 21 -century world.

The FICCI KAS Report highlights IORA's that international platforms concerned with the Blue Economy, IORA is perhaps the most advanced and dynamic in pushing for specific forms of cooperation in this domain. India, as its leading member and with a pivotal position in the region, would do well by putting its policy creativity, institutional energy and financial resources in supporting IORA's programme of action on the Blue Economy and developing partnerships with multilateral and regional institutions and groupings.

Detailed description

IORA adopted the Blue Economy as a major goal at the Council of Ministers meeting held in Perth in October 2014. It identified eight priority areas of cooperation: Fisheries and Aquaculture; Renewable Ocean Energy; Sea, Ports and Shipping; Seabed Exploration and Minerals; Marine Biotechnology; Research and Development; Tourism; Ocean Knowledge Clusters and SIDS and LDCs.

Since 2014, several capacity building programmes have been carried out covering a wide range of areas, including inter alia: fisheries and aquaculture; seafood products safety and quality; seafood handling, post-harvest processing and storage of fisheries and aquaculture products; banking and artisanal fisheries; sustainable management and development of fisheries resources; fish trade; seaport and shipping; maritime connectivity; port management and operations; Marine Spatial Planning; ocean forecasting/ observatory; blue carbon; and, renewable energy.

The First IORA Ministerial Blue Economy Conference (BEC) was held in Mauritius on September 2-3, 2015 in which the Blue Economy Declaration was adopted. Reflecting on the global trends, this declaration underlines the need to harness oceans and maritime resources to drive economic growth, job creation and innovation, while safeguarding sustainability and environmental protection.

Indonesia hosted the Second Ministerial Blue Economy Conference on "Financing the Blue Economy" in May 2017. This resulted in the Jakarta Declaration which suggested optimising the use of existing financial instruments in the IORA region to promote the development of the Blue Economy in the Member-States. The need for new and innovative financing mechanisms and strengthening collaboration between the public and private sectors as well as with the dialogue partners was highlighted.

It is envisaged that the Blue Economy development will be further strengthened in the coming years with the establishment of the Blue Economy Working Group. The preparatory meeting for its establishment was held from in September 2018 in Port Elizabeth, South Africa. This emanated from the IORA Action Plan 2017-2021, adopted at the Jakarta Summit. The Summit also saw the adoption of the Jakarta Concord that reiterated IORA's commitment to promote the development of Blue Economy in the region as a key source of inclusive economic growth, job creation and education, based on the evidence-based sustainable management of marine resources.

The third Ministerial conference on the Blue Economy was held in Dhaka, Bangladesh in September 2019.

Several IORA countries have been taking steps to reduce the degradation of the marine resources, plastic pollution, unsustainable fishing, extraction of non-renewable marine resources, and rising water salinity from desalination. For example, India uses marine plastic waste as raw material for road building. Indonesia has set up a waste insurance clinic offering healthcare in exchange for garbage. UAE follows modular farming practices repurposing brine from desalination. Sri Lanka's has community-based mangrove conservation projects. Seychelles balances economic and conservation objectives through its Marine Spatial Planning (MSP) efforts, and Kenya has adopted plastic ban.

Sustainability has been accepted as the core principle of the Blue Economy. The focus is on enhancing investments in the Blue Economy, ensuring capacity building, and sharing technologies through mutual collaborations among the member-states as well as between them and the dialogue partners of IORA.

Most of the IORA member states have focused Blue Economy and designed their respective national policies and laws that separately address the issues pertaining to sustainable management of species relied upon for food, environment conservation (including land and marine), and climate change. Their implementation, however, is varied.

Bangladesh

Fisheries is one of the most important sectors of the Blue Economy in Bangladesh. Fish adds upto 15.7% of animal protein consumed globally and the value of fish traded by developing countries is estimated at \$25 billion. Marine fish contributes at least 20% of total fish production in the country and about half a million people are directly dependent on this sector.

Shipping and port facilities are considered to be the backbone of the Blue Economy. 80% of global trade by volume and over 70% by value are carried by sea and handled by ports. World seaborne trade is growing by 4% and is projected to triple by 2030. Bangladesh as a coastal state needs to stand out prominently in terms of port facilities and capacities to keep pace with the growing trade.

The main objectives of the Blue Economy in Bangladesh are to promote smart, sustainable and inclusive growth and employment opportunities in the country's maritime economic activities in the short, medium and long-term time frames.

Bangladesh organised an international workshop on the Blue Economy in Dhaka in September 2014, followed by a high-level panel discussion on the side lines of the 71st session of ESCAP in Bangkok. It also hosted a productive International Blue Economy Dialogue in November 2017. In promoting the Blue Economy, Bangladesh has taken a number of steps such as establishing an Oceanographic Research

Institute in the Maritime University, and a National Adaptation Programme of Action as part of developing a strategy to better govern marine resources under its 7th five-year development plan, SDGs Implementation Strategy and Climate Change Resilience Action Plan.

The Blue Economy initiative specifically aims to promote synergies and foster suitable conditions that support specific maritime economic activities and their value chains.

Some threats that Bangladesh faces in its smooth implementation of the Blue Economy are: (i) protecting the area from international smugglers and fish pirates; (ii) preserving mangroves and sea grass (iii) addressing climate change and managing carbon emission; and, (iv) managing sea level rise and change in ecosystem and temperatures, and preventing coral bleaching.

Sri Lanka

Sri Lanka, an island nation, is strategically positioned in the Indian Ocean amidst major commercial trade routes, encompassing a sea area which is seven times larger than its land area. Owing to the geographical and territorial advantage, it has immense potential in the Blue Economy.

Among the 103 rivers flowing through the country, 90% of the land area is covered by the river basins. The Maritime Zone Law No 22 of 1976 provides for the national jurisdiction of the territorial seas and maritime zones of Sri Lanka. Its EEZ is about 517,000 km² in extent. The coastal area of the country is home to 25% of Sri Lanka's population.

Fish is the main source of protein in Sri Lanka amounting to 70% of the total animal protein share. In order to meet the demands of adequate supply of fish, sustainable fishery methods like freshwater farming and mariculture need to be encouraged. Sri Lanka plans to establish the Centre of Excellence on Ocean Sciences and Environment, via the Indian Ocean Rim Association (IORA), with the objective of promoting such collaborations among Indian Ocean Rim countries. The initiative aims to enhance the sustainable utilisation of Indian Ocean resources and increase its role in the economies of its member countries.

There are many components under the Blue Economy in Sri Lanka, such as Fisheries and Nutrient Cycling, Marine Tourism, Sea Transportation, Ocean Energy, Co₂ capture and storage, Minerals and Waste Management. All of these components aim to explore ocean resources.

Maldives

Maldives is one of the many spectacular yet fragile island nations in the Indian Ocean. Its small population of nearly 451,738 lives on a total land area of 298 km². They spread over 1,190 small (habited and inhabited) islands and are dependent on the seas for their livelihood. Traditional occupation of majority of the people is fishing and tourism.

Maldives is a major tuna fishing nation, but the catch has been declining from 100,000 tons in 2006 to approximately 85,000 tons in the recent years.³⁹ It imports all its basic needs (except tuna and coconut) but in recent times hydroponics is becoming popular. Maafahi and Thoddoo, which are agricultural islands, have

³⁹ “**Maldives Fishermen’s Association**”, <http://www.ica-ap.coop/AboutUs/maldives-fishermen%E2%80%99s-association> (accessed 06 June 2019)

now developed large-scale hydroponics projects, which produce green vegetables and grows mushrooms for domestic need.⁴⁰

Tourism is a growth industry and in 2018 the country received a record 1.4 million tourists, 6.8% increase from 2017. As far as tourist demographics are concerned, Europe dominated with a market share of 49%, Asia Pacific with a 42%, the US 5% and China 19.1%.⁴¹ The new government has taken proactive measures to improve tourism promotion and pledged US\$6.7 million, up from US\$2.2 million the previous year.

However, Maldives faces a continuing threat of being submerged from rising sea levels, shrinking coastline and frequent storms. There are fears that by 2050 most of the islands in the country could go underwater rendering large population climate refugees.

The new government in Maldives plans to leverage finance for developing the Blue Economy through public and private and impact investments for sustainable tourism and fisheries, as well as agriculture and renewable energy. The Maldives may also explore Blue Bonds by tapping into capital markets to fund ocean-related environmental projects as also other innovative 'blue' financing instruments such as blue insurance.⁴²

While visiting Maldives in June 2019, PM Modi stated, "We cannot have a more suitable partner than the Maldives in realizing this (that is, Indo-Pacific) vision and for cooperating to benefit from the Blue Economy. Because we are maritime neighbors. Because we are friends."

UAE

UAE is very active in promoting the Blue Economy. It organized the Blue Economy Summit in January 2014 where the Abu Dhabi Declaration was adopted. It describes the Blue Economy as a tool to promote, inter alia, sustainable development, poverty eradication and climate change mitigation in SIDS and coastal countries. The Declaration stresses the importance of an enhanced mechanism for governing the high seas and urges further development of an integrated ecosystem approach to maintain balanced, healthy and productive marine ecosystems, including valuing blue capital and considering blue carbon trading.

The UAE hosted the Sixth World Ocean Summit in March 2019 in Abu Dhabi. The overarching theme of the Summit was "Building Bridges: Finance, Technology and Innovation, and Governance". The conference discussed finance: the role of sovereign wealth funds; blue carbon systems; Islamic finance and the oceans; aquaculture; a focus on cities and waste management; illegal fishing; and, lessons from land economies. In

⁴⁰ "Hydroponics – The Future of Local Farming in the Maldives", <https://www.themaldivesexpert.com/5166/hydroponics-the-future-of-local-farming-in-the-maldives/> (accessed 06 June 2019)

⁴¹ "Maldives Welcomes Record 1.4 Million Tourist Arrivals In 2018", <http://maldives.net.mv/29317/maldives-welcomes-record-1-4-million-tourist-arrivals-in-2018/> (accessed 06 June 2019)

⁴² "Innovative Finance for the Maldives' Sustainable Development"- <https://www.oceanactionhub.org/innovative-finance-maldives%E2%80%99-sustainable-development> (accessed 06 June 2019).

this conference, more than 500 delegates from over 40 countries participated. This shows that the Gulf region is committed to the promotion of sustainable Blue Economy.

Oman

The Sultanate of Oman's vision for developing the Blue Economy encompasses opportunities in Fisheries, Aquaculture, Logistics/Shipping, Offshore Oil and Gas, Offshore Renewable Energy and Marine Mining. Oman is also putting more emphasis on partnerships, especially with the World Ocean Council (WOC). It is seeking the promotion of ocean industries and the adequate investment to advance ocean sustainable development in order to sustain economic diversification goals and the optimum utilisation of its extensive EEZ. Oman is committed to the implementation of UN Sustainable Development Goals.

Australia

The significance of the Blue Economy in Australia's foreign and trade policy is high. Under the chairmanship of Australia, during 14th IORA Ministerial Meeting in Perth on October 9, 2014, the Blue Economy was adopted as a special focus area of IORA.

The contribution of the Blue Economy to the Australian economy has been significant. In 2011-2012, the total contribution of marine-based industries to Australia was AU\$ 47 billion (almost double of the previous decade); it is expected to grow to AU\$ 100 billion by 2025. An additional \$25 billion worth of ecosystem services has been estimated to be provided by Australia's oceans and coasts. Australia's marine industries will contribute around AU\$100 billion each year to the economy, with the oceans and coasts providing a further AU\$ 25 billion worth of ecosystem services, such as carbon-dioxide absorption, nutrient cycling and coastal protection.

Further, the Blue Economy is projected to grow three times faster than Australia's Gross Domestic Product over the next decade, more than doubling its current contribution of \$47.2 billion a year. In Australia, the major ocean industries are: Fisheries and Seafood; Refining of Petroleum from offshore sources; Shipbuilding; Shipping; and Marine Tourism.

Australia has the third largest EEZ. It has been focusing on innovation and sustainable offshore industries through research programmes relating to offshore engineering and technology, seafood and marine, offshore renewable energy system, environment and ecosystems, and sustainable offshore development.

Australia is preparing to host the Australian Marine Science Association conference to focus on health of the oceans and marine life; economic and societal benefits; and, critical Blue Economy challenges. Australia is also seeking collaborative partnerships between industry and marine researchers. Australian universities are focusing on academic and research work on how to achieve a Sustainable Blue Economy.

The foregoing review of developments across the regions indicates that there is growing acceptance of the principles of Sustainability and Inclusivity as well as the imperative to promote the Blue Economy in all its dimensions.

Seychelles

Seychelles' aims to implement the Blue Economy concept at the national level as a framework to foster an integrated approach for sustainable development programmes.

Mozambique

Mozambique, meanwhile, has introduced relevant laws such as the Forestry and Wildlife Law, Fisheries Law and Local Organs Law, Environment Law 1997, and the National Adaption Programme of Action, 2007 that focuses on integrated and sustainable management of 46 the marine environment and actions to mitigate climate change. The IORA nations in their own framework has been battling for sustainable Blue Economy opportunities exploration. It is important for IORA Member States to move together towards Blue Economy Advocacy.

Africa (Some countries in a snapshot)

The Blue Economy in Africa widely refers to the economic activities conducted on and off shores, rivers, lakes, oceans, and seas and seabed. It advocates for reconciliation with nature through sustainable production models based on resilience and adaptability. The Blue Economy, though neglected, could provide a way to reduce Africa's dependence on other countries, outside the continent.

Out of 55 African countries, 38 are coastal countries and over 90% of African exports and imports are transported by sea. The territorial waters under African jurisdiction cover a surface of 13 million km² with exclusive economic zones about 6.5 million km². The continent covers 17% of world's surface of water resources. The Blue Economy has been included in the African Union Agenda 2063. According to an FAO study, the total gross value added of the fisheries and aquaculture sector in Africa is estimated at \$24 billion, which is 1.6% of GDP of all African countries. More than 12 million people are employed in fisheries alone, the largest of the African Blue Economy sectors, providing food security and nutrition for over 200 million Africans.

From mining and oil drilling to fisheries, aquaculture, trade and tourism, Africa has an immense untapped potential in its vast ocean and lake resources. Island countries like Mauritius, Seychelles, Cape Verde have already been engaged in the harnessing of the Ocean Economy. The Blue Economy is making considerable progress in island countries that have a greater historical interaction with the sea. The Blue Economy can become a huge job creator, from artisanal fishing to high-end aquaculture, marine biology and deep-sea mining; and, for most African countries, especially island states, the Blue Economy has the potential to drive their economy itself in the coming years.

Conclusion

In the post- COVID-19 world, 'Blue Economy advocacy' is a necessity for IORA countries as there remains immense potential for the development of resources – including food, livelihoods, tourism, minerals resources, bioprospecting, the mining of seabed resources and 'blue energy'.

There is need for sustained discussion and dialogue between IORA member states, idea sharing for innovative greenfield industry and employment opportunities across a variety of industries.

The opportunity to create sustainable, environment friendly new market options will take IORA Member States towards greater heights. It is time to come together as a unified IORA and reach out across oceans to form 'blue economy' linkages for our national and regional development!

FICCI's First Study Recommendations⁴³

Blue Economy Vision 2025 - Harnessing Business Potential for India Inc and International Partners

The study highlights the need for a balanced approach, combining imperatives for growth and sustainability the value of Public-Private Partnership and deploying technology for optimal development of Blue Economic opportunities for India Inc. and its international partners. For this study, FICCI conducted stakeholder consultations in 3 coastal states-West Bengal, Maharashtra and Tamil Nadu.

FICCI Recommendations

1. A high priority may need to be given to ecological protection and economic democracy.
2. A fundamental consideration should be to balance the requirement of optimization of business potential with the needs and interests of local, particularly coastal, communities.
3. It is only through a broader inclusion of all stakeholders – big, medium and small – that the long-term sustainability and viability of the proposed expansion of Blue Economy opportunities would be ensured.
4. It is essential to adopt a holistic strategy anchored in Public Private Partnership (PPP). It should be designed to accelerate growth, while ensuring sustainable development.
5. The recommended strategy pre-supposes an identifiable mechanism of coordination of all Blue Economy-related planning and policy making in the Union government and state governments in the coastal states as well as in the national and relevant state-level apex chambers of business.
6. A designated nodal ministry or agency at the Centre or Niti Aayog, together with the Ministry of External Affairs and FICCI, should take a sustained lead in this respect to promote and push the desirability of coordination in the future.
7. The government and the private sector will need to make large-scale investments to harness the resources of the sea. Only then there will be marked increase in food from the seas, fisheries, aquaculture, shipping and port facilities, marine technology development and research as well as recovery of minerals, drugs and other assets from the seabed.

⁴³ Blue Economy Vision 2025 - Harnessing Business Potential for India Inc and International Partners

8. Both the national and international dimensions of Blue Economy are inextricably linked. This inter-linkage should be kept in view constantly. Two concrete steps which may be taken on a priority basis are:

- a) An “Atlas of state-wise maritime spatial assets, capacities and planning” may be prepared by the relevant agency;
- b) After a thorough study of how Blue Economy potential is being developed in the Indian Ocean region, a “Detailed Compendium of Best Practices” may be produced by the relevant agency. Both documents will be of immense practical value as instruments in decision-making on the subject in the future.

Following the recommendations from the first study, the second study was convened: **Blue Economy – Global Best Practices: Takeaways for India and Partner Nations**

In this second edition, FICCI along with its institutional partner Konrad Adenauer Stiftung conducted a study to prepare a knowledge report with the aim to make it a repository of international best practices and successful case studies from coastal states of India, leading nations and their companies that are practitioners of Blue Economy. The study has takeaways for Indian Industry as well as instances for public private partnerships. This FICCI-KAS study was launched by Shri V Muraleedharan, Minister for External Affairs and Parliamentary Affairs on 17th January 2020. For this study, FICCI conducted stakeholder consultations in 3 coastal states- Andhra Pradesh, Kerala and Gujarat.

Flowing from the foregoing analysis of this study and on the basis of widespread consultations, a set of recommendations pertaining to strategy, institutional, sectoral and operational issues are given below:

Strategy

The Blue Economy strategy of India should have three critical ingredients:

- Economic growth balanced by sustainable development;
- A Public Private Partnership (PPP) encompassing governments at the Centre and State levels as well as Business and Industry and Civil Society;
- Essentially a multi-disciplinary approach covering all relevant stakeholders.

Institutional

- In order to implement the desired strategy, the country may, in the medium term, need a full-fledged Ministry of Blue Economy.
- However, in the immediate term, the Government is urged to design and put in place an effective institutional mechanism for coordination and leadership, covering all relevant authorities and stakeholders.
- Create a new Blue Economy Policy Unit for external dialogue and cooperation projects and consider locating it in the Ministry of External Affairs.
- Launch a new ‘India Blue Economy Forum’ comprising representatives of Government, Business and private sector experts, for sustained dialogue and follow-up, while ensuring that it functions as a collective public-private partnership enterprise and serves as a bridge linking all the relevant stakeholders. It could be anchored in an appropriate institution or organization such as FICCI.
- Nurture, in a practical and sustained manner, India's multi-faceted ties with relevant multilateral and regional organisations.

- A national Blue Economy accounting system should be developed to obtain a holistic understanding and value of various sectors to provide robust policy prescriptions.

Sectoral

- Undertake focussed studies on the sub sectors of Blue Economy such as marine leisure industry, role of Industry 4.0 technologies, smart river management, marine biotechnology, offshore renewable energy and fisheries related sectors.
- Engage IITs and other institutions to encourage innovation to support Blue Economy
- Explore and popularize the concept of Green and Blue Bonds
- Create Blue Economy Atlas as a valuable business tool for all coastal states and island territories of India (The proposed Atlas would be a compilation of relevant sectors and their economic value).
- While commercial deep-sea mining may not take place in the near future, preparations for legal and contractual formalities should be undertaken.
- On the policy aspect, India should support signing of exploitation contracts when the term of current exploration contracts come to an end. Upon signing of the first exploitation contract it becomes obligatory to set up the commercial arm of the International Seabed Authority, namely the "Enterprise". The main function of the Enterprise is to begin seabed mineral exploitation in the reserved areas simultaneously with other contractors.
- India should explore the possibilities of joint venture operations with the Enterprise, the commercial arm of the International Seabed Authority, as soon as it is established.
- India should be prepared to play a proactive role in the Governing Board of the Enterprise, when established.
- India should also be prepared to seek representation in the Economic and Planning Commission of the ISA once established.
- India should explore partnerships and collaborative ventures relating to lifting, transportation, extractive metallurgy, environmental impact assessment, and restoration techniques.
- India should also explore business opportunities in the area of transportation of materials recovered from deep-seabed, port facilities and storage facilities. It could also devise collaborations with South Africa, Mauritius and Seychelles in infrastructure and logistics arrangements that may be required.
- Indian authorities and industry should plan careful and focussed expansion of capacities, both through the capture and culture route to take advantage of the expanding demand supply gap, which would need an additional global production of over 30 MMTs by 2030.
- Capacity expansion must be pursued with sustainability by paying special attention to ecosystem driven approaches to fish stock management, less polluting feed/disease control methods, high value culture varieties and avoidance of gene pool contamination.
- Adopt measures for reducing wastage through the entire supply chain from catch to plate.
- Introduce better quality assurance and certification system, including hygiene and cold supply chains
- Promote research in marine biotechnology, especially marine metabolites.
- Greater emphasis on improving coastal and marine tourism infrastructure, including connectivity, quality accommodation, hygiene and security.
- Initiate pilot projects for introducing and promoting ecosystem based marine spatial planning, which in due course could be extended to larger ocean spaces.
- Adopt proactive measures to reduce marine litter which also offers business opportunities.

Industry Engagement

- Hold dissemination seminars/workshops in the principal towns of coastal India, in collaboration with experts from interested countries.
- Host an international conference and exhibition on the Blue Economy in New Delhi, involving the member-countries of IORA, BIMSTEC and a few other select countries, with the specific purpose of deepening B-to-B dialogue.
- Encourage the industry partners to progressively integrate the principles of sustainability in their production and value chain management.
- Engage the industry into the Blue Economy discourse for promoting the bottoms up approach and local ownership. They may also be encouraged to develop appropriate roadmaps for promoting sustainable Blue Growth
- Facilitate industry participation in international marine and maritime related Expos, trade fairs and shows.
- Prepare yellow pages for industries, MSMEs, entrepreneurs and start-ups to share expertise, knowledge and opportunities for business.
- The study recommends measures to explore and popularize *Green and Blue Bonds*, undertaking focused studies on marine leisure industry and role of Industry 4.0 technologies, and adoption of ecosystem-driven approaches to fish stock management. While commercial deep seabed mining may not take place in the near future, preparations for legal and contractual formalities should be undertaken. Besides, a number of useful and practical steps to enhance industry engagement with the Blue Economy have been suggested.
- Finally, important recommendations have been made for institutional re-structuring, including the creation of a new “full-fledged Ministry of Blue Economy” in the Central Government, an idea which received particular notice at the time of the study’s launch. Our earnest hope that the Government, industry, experts and media will pay ample attention to our findings. May the study trigger debate and suitable action at policy levels that result in enhanced public-private partnership arrangements at the national level and expansion of India's engagement with partner nations.

FICCI’s Task Force and Core Group on Blue Economy

The members of the Task Force, constituted by FICCI, are listed as below:⁴⁴

S. No	Name	Designation	Organisation
1	Amb. Rajiv Bhatia	Chair, FICCI Taskforce on Blue Economy Distinguished Fellow Former Ambassador	Gateway House
2	Dr. Jyotsna Suri	Past President, FICCI & Co-Chair (Industry)	CMD, Bharat Hotels

⁴⁴ Designation stated at the time of the constitution of Task Force

3	Mr. Shoummo K Acharya	Founder MD & CEO	eTrans Solutions Private Ltd
4	Prof. V.N. Attri	Chair	Indian Ocean Rim Studies, IORA
5	Ms. Rajni Bakshi	Gandhi Peace Fellow	Gateway House
6	Ms. Ruchita Beri	Senior Research Associate	IDSA
7	Mr. Saibal De	Director & CEO	IL&FS Maritime Infrastructure Company Limited
8	Prof. S.K Mohanty	Professor	RIS
9	Amb. Anup Mudgal	Former High Commissioner to Mauritius	
10	Cdr. Dipak Naik	President	Maharashtra Economic Development Council
11	Mr. Shailesh Pathak	CEO	CityInfra Capital
12	Mr. H.P. Rajan	Former Deputy Director (Ocean Affairs), UN	
13	Dr. Vijay Sakhuja	Director	National Maritime Foundation
14	Dr. Samir Saran	Vice President	Observer Research Foundation
15	Dr. P. Sekhar	Chairman	Micro Tech Global Foundation
16	Mr. Pranjal Sharma	Economic Analyst	

The members of the Core group are listed below: ⁴⁵

1. Ambassador Rajiv Bhatia, Chair; Core Group of Experts on Blue Economy and Distinguished Fellow, Gateway House.

⁴⁵ Designation stated at the time of the constitution of Core Group

2. Ambassador Anup Mudgal, Member; Core Group of Experts on Blue Economy and former High Commissioner to Mauritius.
3. Dr. Vijay Sakhuja, Member; Member; Core Group of Experts on Blue Economy; former Director, National Maritime Foundation.
4. Mr. H.P. Rajan, Member; Core Group of Experts on Blue Economy; former Deputy Director, Division for Ocean Affairs and Law of the Sea, United Nations.
5. Prof. V.N. Attri, Member; Core Group of Experts on Blue Economy; Chair, Indian Ocean Studies, IORA, University of Mauritius
6. Ms. Sushma Nair, Member; Core Group of Experts on Blue Economy; Director and Head, Forum of Parliamentarians and Multilateral Engagement, FICCI

